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Observers use facial masculinity to make physical dominance assessments following 100-ms exposure

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Abstract

Research has consistently demonstrated that faces manipulated to appear more masculine are perceived as more dominant. These studies, however, have used forced-choice paradigms, in which a pair of masculinized and feminized faces was presented side by side. These studies are susceptible to demand characteristics, because participants may be able to draw the conclusion that faces which appear more masculine should be rated as more dominant. To prevent this, we tested if dominance could be perceived when masculinized or feminized faces were presented individually for only 100 ms. We predicted higher dominance ratings to masculinized faces and better memory of them in a surprise recognition memory test. In the experiment, 96 men rated the physical dominance of 40 facial photographs (masculinized = 20, feminized = 20), which were randomly drawn from a larger set of faces. This was followed by a surprise recognition memory test. Half of the participants were assigned to a condition in which the contours of the facial photographs were set to an oval to control for sexual dimorphism in face shape. Overall, men assigned higher dominance ratings to masculinized faces, suggesting that they can appraise differences in facial sexual dimorphism following very brief exposure. This effect occurred regardless of whether the outline of the face was set to an oval, suggesting that masculinized internal facial features were sufficient to affect dominance ratings. However, participants' recognition memory did not differ for masculinized and feminized faces, which could be due to a floor effect.

KEYWORDS

aggression, dominance, intrasexual competition, sexual dimorphism

1 | INTRODUCTION

Throughout human evolution, the face has been one of the least occluded body areas and thus an area where observers direct their attention (Calvo & Nummenmaa, 2008; Sell et al., 2009; Sheehan & Nachman, 2014), providing abundant information about a person, such as emotion (Marsh et al., 2005), sexuality (Rule et al., 2009), and health (Foo et al., 2017; Henderson et al., 2016; Little et al., 2011; Phalane et al., 2017; Rhodes, 2006; Schaller, 2015). In addition, observers of both sexes use facial morphology to inform their dominance perceptions (Mileva et al., 2014; Todorov et al., 2015) and assign higher dominance ratings to more stereotypically masculine faces (e.g., Hill et al., 2013; Little et al., 2015). Moreover, both sexes rate photographs of men's faces manipulated to appear more masculine (hereafter masculinized) as appearing more physically dominant than the photographs of the same men's faces manipulated to appear more feminine (hereafter feminized). Masculine faces are those with broader jaws, thicker brow ridges, and longer lower face halves (Thornhill & Gangestad, 2006). Facial features develop differently based on the environment in utero (Fink et al., 2005). For instance, men's faces develop under the influence of testosterone (Marečková et al., 2013; Roosenboom et al., 2018; Verdonck et al., 1999), which plays an essential role in masculinizing facial appearance. With the onset of puberty and increased testosterone production, male facial growth begins to diverge (Bulygina et al., 2006), resulting in the increased maxilla and mandible prognathism relative to females (Thordarson et al., 2006). Thus, during puberty, adolescent boys' level of bioavailable testosterone predicts the probability that naïve observers will identify their facial photographs as male as opposed to female, even after controlling for age (Marečková et al., 2013).

2 | DRAWBACKS OF THE FORCED-CHOICE PARADIGM

To date, most research testing the effects of manipulating facial sexual dimorphism on observers' dominance ratings has relied on forced-choice paradigms.[1] In these experiments, participants are presented with a masculinized and feminized version of the same man's face and must indicate which face appears more physically dominant (e.g., Penton-Voak et al., 2001; Todorov et al., 2015; Watkins et al., 2010). Although these studies support the hypothesis that individuals have the capacity to assess threat from faces, the forced-choice paradigms used in these experiments are subject to demand characteristics (Whitehouse et al., 2002). In forced-choice paradigms, participants are directed to focus attention on two manipulated facial photographs, confounding the situational aspects of the experiment with the participant's response. Participants are forced to choose the more dominant face of the pair, regardless of whether participants would perceive either face as dominant if they were presented outside of this highly artificial situation.

Moreover, by providing the feminized version of the same man's face as a reference upon which participants base their comparisons, the results of these experiments can only demonstrate that on-average masculinized men's faces are rated as more dominant than the feminized version of the same man's face. Forced-choice paradigms do little to determine if observers truly perceive masculinized faces as more physically dominant, reducing generalizability to real-world situations. In addition, providing participants with an unlimited amount of time to make their responses increases the likelihood that participants will attend to the manipulated facial traits. Therefore, forced-choice inhibits researchers from inferring how facial masculinity affects social interaction and subsequent decision-making. The limitation of this paradigm represents a large gap in the knowledge base of perceived male dominance, preventing researchers from understanding the cognitive processes that precede observers' threat and dominance evaluations. In the current study, we seek to correct the potential confounds of forced-choice paradigms.

3 | SALIENCE OF FACIAL MASCULINITY ON DOMINANCE APPRAISALS

Automatic attentional processes may underlie perceived dominance evaluations. For instance, a salient cue biases the processing of incoming information with speed and efficiency (Posner et al., 1980). To test if individuals automatically attend to masculine facial characteristics, it is first necessary to determine whether these facial features are perceptible when presented for short durations. If humans possess an attentional bias toward cues that signal the presence of a physically dominant and potentially threatening individual in their environment (i.e., a masculinized face), then it is first necessary to establish that they are able to use facial masculinity to assess physical dominance from a glimpse toward the target face. Yet to date, no experiments have tested whether humans can use facial masculinity to make dominance attributions following brief exposure.

Observers evaluate faces on dominance, the perceived physical strength of the individual, as well as valence, the perceived trustworthiness of the individual (Oosterhof & Todorov, 2008). Observers across a wide variety of cultural backgrounds use these lower-level dimensions when formulating first impressions from facial photographs (Jones et al., 2018). Together, valence and dominance judgments inform observers of individuals' threat potential, such that those judged to be high on dominance and low on valence (i.e., those that should be avoided) are judged as threatening (Oosterhof & Todorov, 2008). Many studies have indicated that more masculine faces, determined either by raters or through objective measurements, are rated as more dominant (e.g., Hill et al., 2013; Mefodeva et al., 2020; Penton-Voak et al., 2001; Todorov et al., 2015), stronger (Sell et al., 2009; Toscano et al., 2014; Van Dongen & Sprengers, 2012), and more threatening (Han et al., 2017). Observer's dominance ratings appear to increase linearly with the extent of facial masculinization (Mefodeva et al., 2020). Moreover, observers appear to possess the capacity to accurately assess salient emotional features such as aggressiveness as a means of rating threat potential when faces are presented for as little as 39 ms (Bar et al., 2006; Carré et al., 2009; Todorov et al., 2009), suggesting that a fleeting glance is enough time for observers to take in relevant information. Other studies have suggested that stimulus salience affects observers' memory for presented faces (Becker et al., 2005).

Dominance perception is probably not only detected from transient exposure, but it may also create a lasting trace in memory. Attention to objects in the natural environment can enhance the ability to store featural information in long-term memory (Hollingworth & Henderson, 2002). In support of this, men demonstrate enhanced memory for the location of attractive female faces (Becker et al., 2005) which may reflect adaptations for locating suitable mates (Becker et al., 2005). If the attentional system has evolved to act in conjunction with the memory system to process and

[1]cf. Sherlock et al. (2017) for another experiment on the effects of facial masculinity that minimized demand characteristics.

store information about objects, then it could be hypothesized that memory is another process underlying the perceived dominance of male faces. An adaptation to remember cues of facial masculinity and associate them with physical dominance and threat could promote responses in observers that could mitigate the threat, such as demonstrating deference or avoiding the physically dominant individual. Therefore, we would expect that individuals should demonstrate a predisposition to first identify the more salient trait of dominance and then store the more masculinized faces in long term memory.

4 | STUDY PURPOSES

With little evidence to suggest that dominance is a trait that can be perceived in isolation, the first purpose of the experiment was to test if men assigned higher dominance ratings to masculinized faces compared to feminized faces when they were presented individually. If facial sexual dimorphism is a salient factor that affects observers' assessments of dominance, then participants should rate masculinized men's faces as more dominant irrespective of whether the feminized version of the same face is also presented. In support of this hypothesis, Van Dongen and Sprengers (2012) computed objective measures of facial masculinity using geometric morphometrics and found a strong positive correlation between facial masculinity scores and observers' estimates of the photographed men's upper body strength and dominance, when these faces were presented individually. Similarly, Carré et al. (2009) manipulated, the face width-to-height-ratio, one aspect of facial morphology predictive of a predisposition for aggressive behavior (cf. Geniole et al., 2015; Haselhuhn et al., 2015). The authors presented target faces individually and found that faces manipulated to be relatively wider were rated as more aggressive. Therefore, we seek to address the issues caused by using forced-choice paradigms, and reduce the potential for introducing demand characteristics into the experimental design, by presenting observers with faces manipulated on sexual dimorphism individually.

The second purpose of the experiment was to test if men could discriminate levels of physical dominance when masculinized and feminized faces were presented for short durations (i.e., 100 ms), simulating a brief glance toward the target faces (Todorov et al., 2009). Previous research has demonstrated that observers are able to process salient information from faces, such as physical attractiveness when they are presented for as little as 20 ms (Olson & Marshuetz, 2005; Willis & Todorov, 2006). As mentioned above, observers appear to possess the capacity to accurately assess salient features related to aggressive intent when rating threat potential. These raters can make assessments in as little as 39 ms (Bar et al., 2006; Carré et al., 2009; Todorov et al., 2009). Research by Todorov et al. (2009) suggest that exposure times longer than 100 ms do not significantly improve the accuracy of the observers' threat assessments (Todorov et al., 2009). As such we elect to adhere to the recommendations of Todorov et al. and present faces for 100 ms.

The third purpose was to assess if facial masculinity affects observers' recognition memory for presented faces. As highlighted, we expect masculinized men's faces to be more salient because of their expected association with the individuals' physical dominance. Previous research has demonstrated that male listeners demonstrate better recognition memory for information previously spoken by lower-pitched, more stereotypically masculine sounding male voices (Albert et al., 2018), and that listeners are more sensitive to the identity of speakers when their voices are manipulated to have a lower pitch than when they are manipulated to be a higher pitch (Zhang et al., 2020). This would suggest that men's better memory for lower-pitched voices (Zhang et al., 2020) or the information spoken by a lower-pitched voice (Albert et al., 2018) may be due to the fact that this auditory information was more salient at encoding, perhaps because it cued the speakers' physical dominance (e.g., Jones et al., 2010; Puts et al., 2016). Within the visual domain, recent research has demonstrated that naïve observers are more likely to remember the faces of untrustworthy individuals in a recognition memory test, perhaps because remembering such individuals would promote future avoidance of them (Mattarozzi et al., 2015). Craig et al. (2019) found that during an aggressive-intent categorization task, participants were faster and more accurate at classifying a bearded male as angry compared to a clean-shaven one, demonstrating that males use secondary sexual characteristics to assess formidability and perceive males with facial hair as being more formidable. Conversely, Sherlock et al. (2017) found that increased facial masculinity predicted observer's explicit dominance ratings, but not their implicit responses after being exposed to cues of physical dominance. Therefore, the third purpose of our experiment was to test if men demonstrated better recognition memory for masculinized men's faces over feminized ones.

5 | HYPOTHESIS

Based on the literature reviewed above, and our outlined purposes, we predicted that men would assign significantly higher dominance ratings to masculinized men's faces when they are presented one at a time (purpose 1) for 100 ms (purpose 2). Furthermore, we also expected that men would be more accurate when indicating that they had seen a face from the rating phase when it was masculinized than when it was feminized (purpose 3) and to be more confident in their recognition of masculinized faces. Additionally, we predicted that masculinized and feminized internal facial features would be sufficient to produce the expected differences in observers' dominance ratings. To test for this, we cropped the facial photographs to an oval, to control for facial contour and assign half ($n = 48$) of the participants to view these stimuli. We expected that men who were presented with complete facial photographs would assign higher dominance ratings to masculinized men's faces than those men who saw only the internal features, because of the effects that masculinized facial contour would have on dominance ratings. We made no predictions regarding differences in men's recognition memory between conditions.

6 | METHOD

6.1 | Participants

In this study, we chose to use only young men, because research on intrasexual competition would suggest that males are more sensitive to signals of threat potential (Charlton et al., 2013), due to a history of strong intrasexual competition (Kruger & Nesse, 2006; Puts et al., 2016; Wilson & Daly, 1985). We expect that this sensitivity to conspecifics' threat potential should be greatest during young adulthood when intrasexual competition is most intense. Participants were 96 male students from Boston University between the ages of 18 and 27 (M_{age} = 20.16, SD = 2.02). We consulted studies investigating the effects of facial masculinity on observers' implicit responses to determine our sample size (Ohlsen et al., 2013; Watkins et al., 2010). The ethnic composition of the sample was as follows: Caucasian (54%), Asian (32%), Latin American (18%), Black (12%), South Asian (9%), Arab West Asian (4%), South East Asian (1%). Participants were primarily recruited through the institution's research participation pool and were compensated with course credit. The remaining participants were recruited via advertisements placed throughout the Boston University campus, and through online job adds for Boston University students and received 20.00 USD for participation. The study and all materials were approved by Boston University IRB in accordance with the declaration of Helsinki for the ethical treatment of human subjects.

6.2 | Materials

6.2.1 | Photographs

We used 57 photographs from the Nipissing University Face Set and 33 from the London Face Set (DeBruine & Jones, 2017). For the Nipissing University Face Set, as part of a larger study on health and human mating, 167 men between the ages of 18 and 39 (M_{age} = 22.71 SD_{age} = 4.71) were photographed from a distance of 2 m with a neutral facial expression. For the Nipissing University Face Set, selection criteria for the current investigation were that the photographs were of Caucasian men with no facial scars, jewelry, and minimal to no facial hair. The Caucasian men from the London Face Set (DeBruine & Jones, 2017) were between the ages of 18 and 48 (M_{age} = 27.51, SD_{age} = 7.41). For both face sets, participants were photographed with a neutral facial expression. Photographs were originally 4608 × 3456 pixels in size. These were cropped and resized to match the photographs of the London Face Set (DeBruine & Jones, 2017). Between the Nipissing University Face Set and the London Face Set a total of 90 facial photographs were transformed (DeBruine & Jones, 2017).

6.2.2 | Stimulus creation

We used Psychomorph (version 6) to delineate the shape of the face by placing 189 landmark points along the contours of major facial features. Next, we aligned the position of the pupils of each photographed face on the same *x-y* plane. Then we used the Caucasian male and female prototype facial photographs provided by DeBruine and Jones (2017) to manipulate the sexual dimorphism of the 2D face shape of the facial photographs. These prototype male and female facial photographs were created by averaging the *x-y* points for all Caucasian males' facial photographs together, and all Caucasian female facial photographs together to create the prototypical male and female facial photographs. To create the masculinized and feminized versions of the facial photographs, 75% of the linear differences in the 2D shape between symmetrized versions of the male and female prototype faces were added to or subtracted from each original photograph (e.g., Jones et al., 2009). Technical details of the computer graphic methods used to transform two-dimensional face shape in this way are given in Tiddeman and Perrett (2001) and Perrett et al. (1998). This process generated two faces per original facial photograph, resulting in 180 morphed faces (i.e., 90 masculinized and 90 feminized male faces). Images were then masked around the outline of the face so that hair and clothing cues were not visible. For the rating phase, 20 masculinized and 20 feminized faces were randomly drawn from the larger pool and presented to participants. See Figure 1 for an example of the facial photographs used in the experiment.

To control for the effects that masculinized and feminized facial contour had on participants dominance ratings we used GIMP (version 2.10.10), to create a second set of stimuli in which the contour of all photographs were set to ovals. These stimuli were presented to half of the participants to control for affects that the outer face shape may have had on physical dominance ratings. The facial stimuli were presented in the center of the computer screen and subtended 6.08° of visual angle horizontally and approximately 7.60° of visual angle vertically for both the rating and recognition phases. For the rating phase, presentation of the faces was randomly distributed across participants such that each participant saw a random selection of 20 unique identities of men with masculinized faces and 20 unique identities of men with feminized men's faces. Half of these faces were from the Nipissing University Face Set, while the other half was from the London Face Set (DeBruine & Jones, 2017).

6.3 | Procedure

Participants were tested individually. All participants had normal or corrected to normal vision. The visual acuity of all participants was tested using a Snellen vision screening test. The visual acuity of participants was ($M_{Snellen}$ = 23.83, $SD_{Snellen}$ = 7.35). To participate in the current experiment participants' visual acuity could not be above a Snellen ratio of 20/40. No participants were excluded due to poor

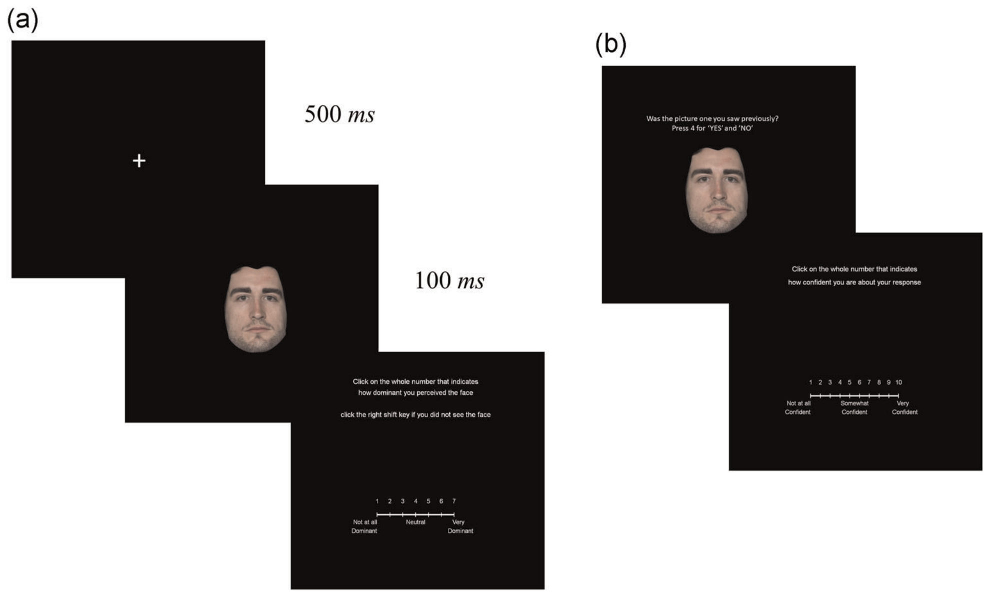

FIGURE 1 Trial schematic for the rating (a) and recognition phase (b) [Color figure can be viewed at wileyonlinelibrary.com]

visual acuity. All testing took place at a single computer station (Dell XPS 8930 Tower Desktop—8th Gen). We used a chin rest to ensure that all participants sat 50 cm from the computer monitor. Participants viewed the facial photographs on an Asus 24 LED FHD computer monitor, with a 60 Hz refresh rate. Psychophysics toolbox 3 (version 3.0.15) with Matlab (2018a) was used to present stimuli and record participants' responses.

6.3.1 | Rating phase

Figure 1a provides a complete schematic of a rating trial. Participants completed 40 trials of the rating phase. Each trial began with the presentation of a fixation cross in the center of the screen for 500 ms. The fixation cross subtended 0.57° of visual angle vertically and horizontally. This was followed by the presentation of a face for 100 ms. Following the presentation of the face, participants were presented with a Likert-type rating scale and rated the physical dominance of each face from 1 (not at all dominant) to 7 (very dominant). Participants were told that a physically dominant man was defined as one who would probably win a fistfight against the average man. After making their rating participants proceeded to the next trial.

6.3.2 | Recognition phase

Following the rating phase, participants completed 40 trials of a surprise recognition memory task. Figure 1b provides a complete schematic of a recognition trial. Participants were presented with 40 unique face identities on the screen one at a time. Half of these faces were randomly selected from the faces presented during the rating phase ("targets"). The other half were new faces ("lures") not previously presented in the rating phase. Half of the targets were masculinized faces, while the other half were feminized faces. The two types were also equally divided among the new face lures. By designing the recognition memory phase this way, we were trying to prevent participants from committing incorrect acceptances caused by seeing the facial photograph of the opposite dimorphism manipulation. After the presentation of a face, participants were asked to indicate whether they recognized the image as a face presented during the previous task. Participants pressed "4" on the keypad to indicate a correct target and "6" to indicate a new lure. Each face remained on the screen until they made their decision. Following their decision, participants rated how confident they were in their old/new classification using a 10-point Likert rating scale ranging from 1 (not at all confident) to 10 (very confident). After rating their confidence, the next trial began.

6.4 | Analytic plan

Analysis was conducted in *R* (version 3.6.2; R core team). For the rating phase, we used the *lmer* function from the package, *lme4* (Bates et al., 2015) to conduct a mixed effects linear regression with maximum likelihood estimation. For the regression, participant identity, photographed individual identity and trial number were random effects. The random slope of participant identity was allowed to vary according to sexual dimorphism. Face sexual dimorphism (i.e., masculinized or feminized), face contour (full face or oval), face set (London face set or Nipissing University face set) along with their interactions were the fixed effects. Participants' dominance rating (1 = not at all dominant to 7 = very dominant) was the dependent variable for this analysis. To assess the amount of variance explained

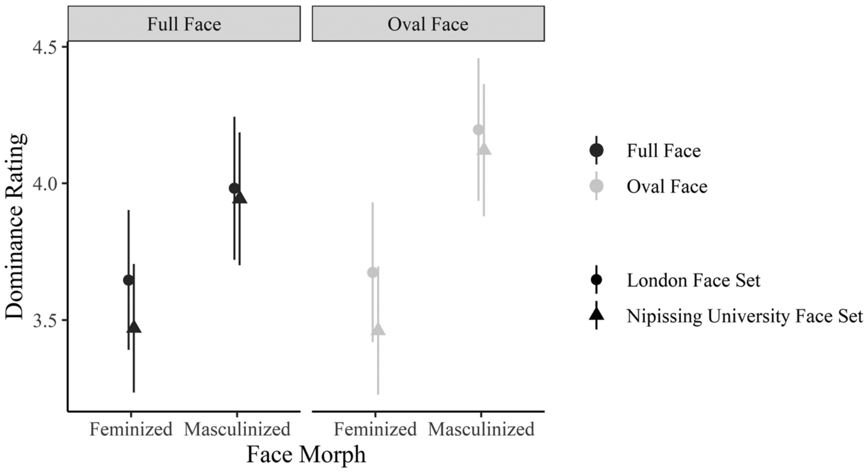

FIGURE 2 Observer's dominance ratings as a function of sexual dimorphism, face set and face contour

by our fixed and random effects, we computed Pseudo R^2 using the *r.squaredGLMM* function from the Multi-Model Inference (*MuMIn*) package (Barton & Barton, 2019).

To analyze the results of the recognition memory phase we conducted a repeated measures analysis of variance (ANOVA) using the *ez* package (Lawrence, 2016). Because we wanted to reduce the effects that careless responding had on our analysis of participants' recognition memory, participants with an accuracy below chance in the recognition phase (i.e., ≤50%) were removed from the analysis. This resulted in the exclusion of 21 participants from the analysis of participants' sensitivity and confidence ratings. For ANOVAs we report the generalized eta square as our estimate of effect size (Bakeman, 2005). The *d'* score for masculinized and feminized faces were calculated for each participant. This measure was computed based on the hit (H) and false alarm (FA) rates, where $d = z(\text{H}) - z(\text{FA})$ (Macmillan & Creelman, 1991; Stanislaw & Todorov, 1999). *d'* score served as the dependent variable. Additionally, we computed participants' mean confidence ratings for correct trials in the recognition memory task.

7 | RESULTS

7.1 | Rating

The fixed effect of sexual dimorphism was a significant predictor of participants' physical dominance ratings ($b = 0.34$, SE = 0.09, $t = 3.54$, $p < .001$). See Figure 2 for an illustration of observer's ratings. However, neither the fixed effect of face contour ($b = 0.03$, $SE = 0.15$, $t = 0.19$, $p = .85$), the fixed effect of face set ($b = -0.18$, $SE = 0.12$, $t = -1.43$, $p = .15$), nor any of the interactions amongst the fixed effects (*bs* < 0.19, *ts* < 1.39, $p > .17$), predicted participants physical dominance ratings. The total proportion of variance explained by both the fixed and random effects was 35.24%. When only the fixed effects were considered, the total proportion of variance explained was 3.72%. see Table 1 for a report of the regression coefficients, *t* values, 95% confidence intervals, and Pseudo R^2 of the fixed effects, and Table 2 for the variance and standard deviations of the random effects.

7.2 | Recognition

We began by conducting a one-samples *t* test to assess whether participants sensitivity to previously presented faces was above chance (i.e., greater than 0). Participants sensitivity for previously presented faces was significantly above chance levels, $t(145) = 13.60$, $p < .001$ $d = 1.13$.

To assess if observers demonstrated better recognition memory for masculinized men's faces, we conducted a 2 (Dimorphism: masculinized, feminized) × 2 (Face Contour: full face, oval) mixed factorial ANOVA in which observers' sensitivity (*d'*) served as the dependent variable. Neither the main effect of dimorphism, $F(1, 71) = .31$, $p = .58$, $\eta_G^2 = 0.003$, ($M_{\text{fem}} = 0.25$, $SD_{\text{fem}} = 0.23$, $M_{\text{masc}} = 0.23$, $SD_{\text{masc}} = 0.20$), nor the main effect of condition ($M_{\text{oval}} = 0.24$, $SD_{\text{oval}} = 0.22$, $M_{\text{full}} = 0.25$, $SD_{\text{full}} = 0.22$), $F(1, 71) = .10$, $p = .75$, $\eta_G^2 < 0.001$, were significant. The dimorphism by condition interaction was not significant, $F(1, 71) = 0.02$, $p = .88$, $\eta_G^2 < 0.001$.[2] We conducted a 2 (Dimorphism: masculinized, feminized) × 2 (Face Contour: full face, oval) mixed factorial ANOVA in which observers' confidence served as the dependent variable. Neither the main effect of dimorphism, $F(1,69) = 0.31$, $p = .58$, $\eta_G^2 = 0.003$, ($M_{\text{fem}} = 5.82$, $SD_{\text{fem}} = 1.68$, $M_{\text{masc}} = 5.68$, $SD_{\text{masc}} = 1.57$), nor the main effect of condition, $F(1, 69) = 0.01$, $p < .91$, $\eta_G^2 < 0.001$, ($M_{\text{oval}} = 5.73$, $SD_{\text{oval}} = 1.66$, $M_{\text{full}} = 5.77$, $SD_{\text{full}} = 1.59$) was significant. Neither was the interaction between these factors, $F(1, 69) = 1.10$, $p = .30$, $\eta_G^2 = 0.001$.[3]

[2]Note that the pattern of results for the mixed factorial ANOVA were unchanged when all participants were included in the analysis: all *Fs* $(1, 95) < 0.40$, $p > .52$, $\eta_G^2 < 0.003$.

[3]Note that the pattern of results for the mixed factorial ANOVA were unchanged when all participants were included in the analysis: all *Fs* $(1, 94) < 2.20$, $p > .14$, $\eta_G^2 < 0.02$.

TABLE 1 Coefficient, standard errors, their 95% CI, *t* statistic, and *p* values for the fixed effects and their interactions

	b	*SE*	*df*	*t*	*p*	LL	UL	R^2m	R^2c
Intercept	3.65	0.13	193.03	28.01	<.001	3.39	3.90	0.04	0.35
Sexual dimorphism	0.34	0.09	189.84	3.54	<.001	0.15	0.52		
Face contour	0.03	0.15	123.38	0.19	.85	−0.26	0.31		
Face set	−0.18	0.12	162.36	−1.43	.15	−0.42	0.06		
Sexual dimorphism × face contour	0.19	0.13	189.38	1.39	.17	−0.08	0.45		
Sexual dimorphism × face set	0.14	0.10	3497.98	1.31	.19	−0.07	0.34		
Face contour × face set	−0.04	0.10	3494.49	−0.35	.73	−0.24	0.17		
Sexual dimorphism × face contour × face set	<0.001	0.15	3501.52	0.00	1.00	−0.29	0.29		

Abbreviations: CI, confidence interval; LL, lower limit; UP, upper limit.

8 | GENERAL DISCUSSION

Our hypothesis regarding men's physical dominance ratings were confirmed. Across both contour conditions, men assigned significantly higher physical dominance ratings to individually presented masculinized men's faces, compared to individually presented feminized faces. This effect occurred regardless of the face set that the face was drawn from, indicating that the sexual dimorphism manipulation, and not the other factors affected observers' dominance ratings. The ability to judge dominance was not affected by the brief (100 ms) presentation time. This would suggest that even under brief visual exposure, men can capture cues for physical dominance. Men's ability to assess the physical dominance of other men from their faces remains fairly consistent regardless of whether men are presented with the face with its outline or with faces in which the outline has been set to fit an oval, thus erasing some of the width and height information. The results imply that observers are primarily relying on internal facial features when formulating their physical dominance assessments. Together, the results of the rating task of our experiment suggests that men use facial sexual dimorphism under conditions of brief visual exposure to formulate their physical dominance perceptions and that these perceptions are primarily based on internal facial features. Although the current study relied on explicit ratings, it goes beyond previous investigations, because observers were not given an unlimited amount of time to inspect each face. Rather, the time of stimulus presentation was just within the limits of the ability to make an accurate assessment (Todorov et al., 2009).

TABLE 2 Variance and standard deviation of the random effects

Groups	Name	Variance	*SD*	*r*
Participant	Intercept	0.38	0.62	
	Sexual dimorphism	0.17	0.41	−.25
Face identity	Intercept	0.20	0.45	
Trial number	Intercept	0.01	0.09	
Residual		1.26	1.12	

The above findings compliment research suggesting that individuals can accurately assess physical strength (Toscano et al., 2014; Van Dongen & Sprengers, 2012) and aggressiveness (Carré et al., 2009; Little et al., 2015; Sell et al., 2009) from faces, and that these assessments are related to facial sexual dimorphism. Previous research has shown that sexually dimorphic facial features are associated with testosterone during development (Marečková et al., 2013; Roosenboom et al., 2018; Verdonck et al., 1999; Welker et al., 2016; cf. Hodges-Simeon et al., 2016, 2018, 2020) and that testosterone levels are associated with increased aggression during challenge (Gray et al., 2019) and muscle mass (e.g., Griggs et al., 1989). Therefore, an adaptation to rapidly assess conspecific's dominance from faces would benefit its bearers by allowing them to avoid interactions with individuals who could cause them serious physical harm.

We would also predict that masculinized faces, indicative of men with greater physical dominance, would leave a lasting trace in memory. However, observers did not differ in their ability to recognize masculinized faces over feminized ones. Moreover, participants were not more confident in their recognition memory for previously presented masculinized men's faces over feminized ones. During the rating phase, the number of faces presented to participants should have contributed to task difficulty. Perhaps equally important, participants were exposed to each face for only 100 ms, which may have been insufficient to encode each face into long-term memory. In addition, the task was likely made even more difficult because participants were not instructed to remember the presented faces. To reduce the likelihood of producing a floor effect, future investigations should assess whether presenting observers with the faces for longer durations or presenting participants with fewer faces at encoding improves memory.

Our study was limited in that we only evaluated men's ratings of and recognition memory for masculinized and feminized men's faces;

however, in future investigations we intend to collect data from both sexes. The sex differences in strength make women more vulnerable to aggression and thus suggest greater female sensitivity to threat (e.g., Geniole & McCormick, 2013; Lassek & Gaulin, 2009). Future studies should aim to test women's ability to assess physical dominance from masculinized and feminized men's faces while controlling for the affects that masculinized and feminizing these faces has on women's attractiveness perceptions. Other studies could prime participants with victory or defeat in a lab-based competition and then have them complete a similar face rating and recognition memory test to assess if individuals primed with defeat are more sensitive to cues of masculinity than those primed with victory (Watkins & Jones, 2012). Denson et al. (2020) found that after playing violent video games, men reported being less likely to back down from a physical confrontation with a physically masculine target male, suggesting that exposure to violence heightens self-perceived formidability.

In future investigations, researchers should seek to confirm that manipulating the degree of facial sexual dimorphism scales linearly with observer's dominance perceptions, even when these faces are presented for extremely short durations (Mefodeva et al., 2020). Further investigations could manipulate sexually dimorphic facial traits (e.g., lower face length, brow ridge prominence) individually and evaluate which manipulation produces the greatest changes in observers' dominance ratings (Dixson, 2018; Bulygina et al., 2006; Thordarson et al., 2006). This would allow researchers to gain a more nuanced understanding on which characteristics observers are basing their dominance assessments on and could inform future research on male intrasexual competition.

8.1 | Conclusions

The results of our experiment demonstrate, for the first time, that men assign higher physical dominance ratings to masculinized men's faces when they are presented individually. Moreover, we show that men use facial sexual dimorphism to make dominance attributions after only being exposed to each face for 100 ms. Our results suggest that men rely on internal facial features when making their dominance assessments. This provides some of the strongest evidence to date that men *perceive* masculinized faces as belonging to more physically dominant men and provides insights into the types of cues men use during dominance contests.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/R9UXE.

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