Supplementary Online Material:

A facial action imposter: How head tilt influences perceptions of dominance from a neutral face

Zachary Witkower

Jessica L. Tracy

The University of British Columbia

Please Address Correspondence to:

Zachary Witkower
University of British Columbia
2136 West Mall
Vancouver, BC Canada V6T 1Z4
Zak.Witkower@psych.ubc.ca

Study S1: Eye Gaze Direction

Prior research suggests that a downward-head tilt combined with eye gaze averted towards the ground or with eyes closed is perceived as submissive or shameful (Mignault & Chaudhuri, 2003; Rule et al., 2012; Tracy, Robins, & Schriber, 2009; Tracy & Matsumoto, 2008). In contrast, studies that paired a downwards-head tilt with eye gaze directed toward perceivers found increased perceptions of dominance and dominance-related constructs (Hehman, Leitner, & Gaertner, 2013; Toscano, Schubert, & Giessner, 2018). We therefore pre-registered the prediction that a downwards-head tilt would increase perceptions of dominance, compared to a level and upwards head angle, only when eye gaze was directed toward observers (see osf.io/tn5db).

Method

Participants

Sixty-eight adults were recruited from Amazon Mechanical Turk, but 18 individuals who failed an attention check were excluded from analyses, resulting in a final sample of 50 participants (32% female; age range=19-57, Median=30.5 years). For power analysis, see osf.io/tn5db.

Stimuli and procedure

Stimuli were similar to those used in Study 1, with two exceptions. First, we added three new images that were identical to the three used in Study 1 but with the target's eye gaze averted away from perceivers (see Figure S1), always in the same direction as head tilt (i.e., gaze was averted downward in the downward-tilt condition, upward in the upward-tilt condition, and to the side in the level-head condition). Second, images portrayed the target from the waist up rather than head only, to minimize the salience of eye gaze and head tilt, making this design a

more conservative and ecologically valid test of our hypotheses. Participants were shown all six images in a randomized order and judged the dominance of each using the same measure as was used in Study 1 (αs across conditions>.85).

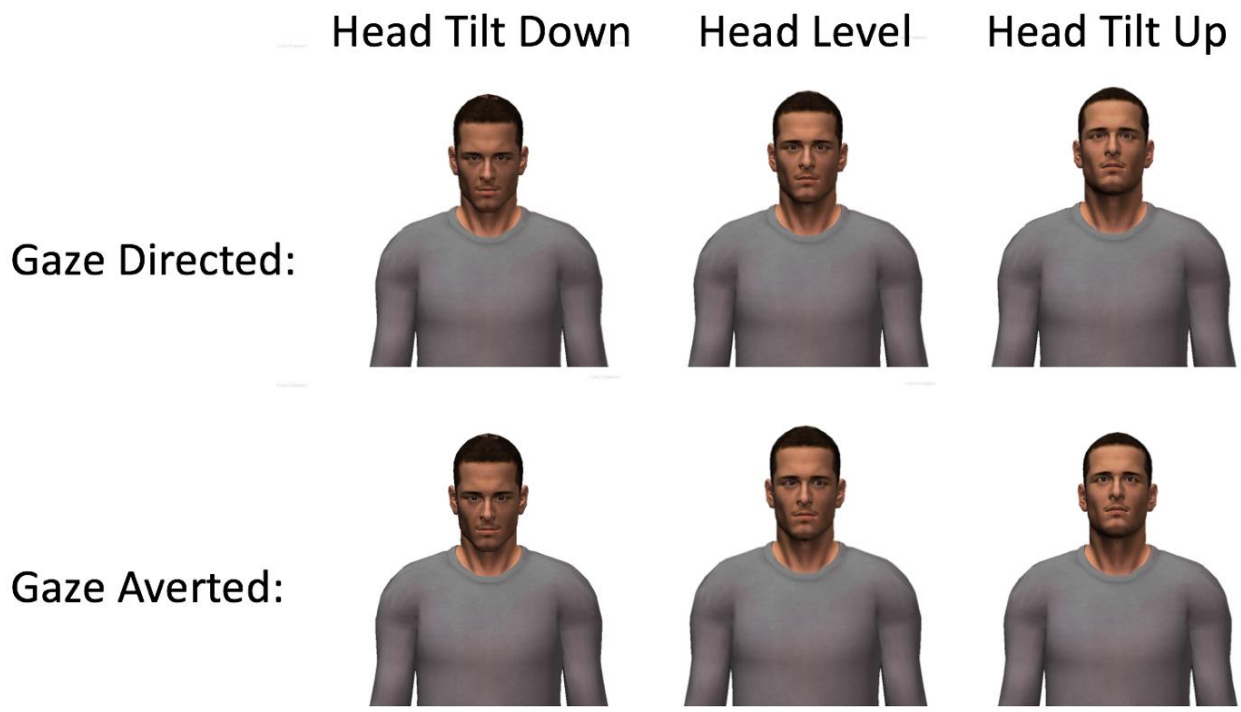

Figure S1. *Stimuli used in Study S1.*

Results and Discussion

A 3 (Head tilt: up vs. level vs. down) x 2 (Gaze: directed vs. averted) repeated measures ANOVA uncovered significant main effects of eye gaze, $F(1,49)=23.97$, $p<.001$, $\eta_p^2=.33$, and head tilt, $F(2,98)=9.05$, $p<.001$, $\eta_p^2=.16$, but these were qualified by an eye-gaze by head-tilt interaction, $F(2,98)=6.54$, $p=.02$, $\eta_p^2=.12$ (see Figure S2).

Examining effects separately for each eye-gaze condition revealed a significant effect of head tilt on perceptions of dominance when eye gaze was directed toward perceivers, $F(2,100)=10.20$, $p<.001$, $\eta_p^2=.17$, indicating that downwards-head tilt significantly increased

perceptions of dominance compared to the neutral and upwards angles (see Figure S2; *ps*<.001, *ds*=.74 and .66 for head level and up, respectively; the difference between upward and neutral head angles was not significant, , *p*>.99 , *d*=.10). In contrast, when eye gaze was averted, head tilt did not significantly influence perceptions of dominance, $F(2,98)=.68$, $p=.49$, $\eta_p^2 =.01$, *p*s≥.55, *d*s≤.19.

These results suggest that the combination of downwards head tilt and directed gaze increases perceptions of dominance, whereas the same head angle with gaze averted does not have such an effect.

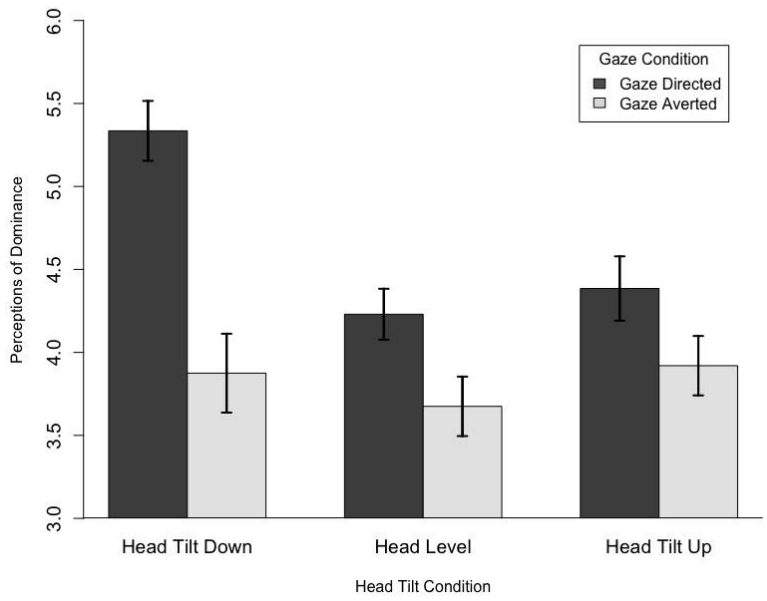

Figure S2. *Mean* p*erceptions of dominance by condition, Study S1.*
Note. Error bars illustrate +/-1SE from the mean.

Study S2: Manipulating Visible Facial Width-to-Height Ratio

In Study S2 we sought to stringently test the visible FWHr hypothesis by manipulating vFWHr independently of head-tilt direction. We preregistered our hypothesis that a downward-head tilt would increase dominance perceptions even when controlling for changes in vFWHr (osf.io/tn5db). Stated differently, if the head is tilted down but vFWHr is not increased, we predicted that downwards-head tilt would still increase perceptions of dominance—in contrast to predictions that emerge from the vFWHr hypothesis.

Method

Participants and procedure

Six-hundred, thirty-five adults from Amazon Mechanical Turk participated in the current study; 33 failed an attention check and were not included in analyses, as per our pre-registration, resulting in a final sample of 602 participants (52.3% female; age range=18-72, Median=31 years). For power analysis, see osf.io/tn5db. Participants were randomly assigned to view one of three stimulus images and indicate their perceptions of the target's dominance using the same measure as in Study 1. We used a between-subjects design to ensure that responses would not be affected by prior judgments, given the similarity in appearance between the two stimuli featuring head-tilt downward.

Stimuli

We developed stimuli in which vFWHr was systematically manipulated independently of head-tilt angle. We began with the two stimuli used in Study 1, in which the avatar target held his head at a neutral angle, with a vFWHr of 1.777, and the one in which he tilted his head tilted downward ten degrees, resulting in a vFWHr of 1.834. Visible FWHr was determined on the basis of the same facial landmarks as in past research (see Hehman et al., 2013). We then created

a third target stimulus, using Poser Pro, in which the avatar tilted his head downward 10 degrees while his face was slightly adjusted to *decrease* vFHWr compared to the neutral-head angle target, resulting in a vFWHr of 1.731. Although tilting the head downward naturally increases vFWHr, this third stimulus portrayed a head tilted downward with an artificially adjusted face such that vFWHr was *decreased* compared to both other conditions (see Figure S3).

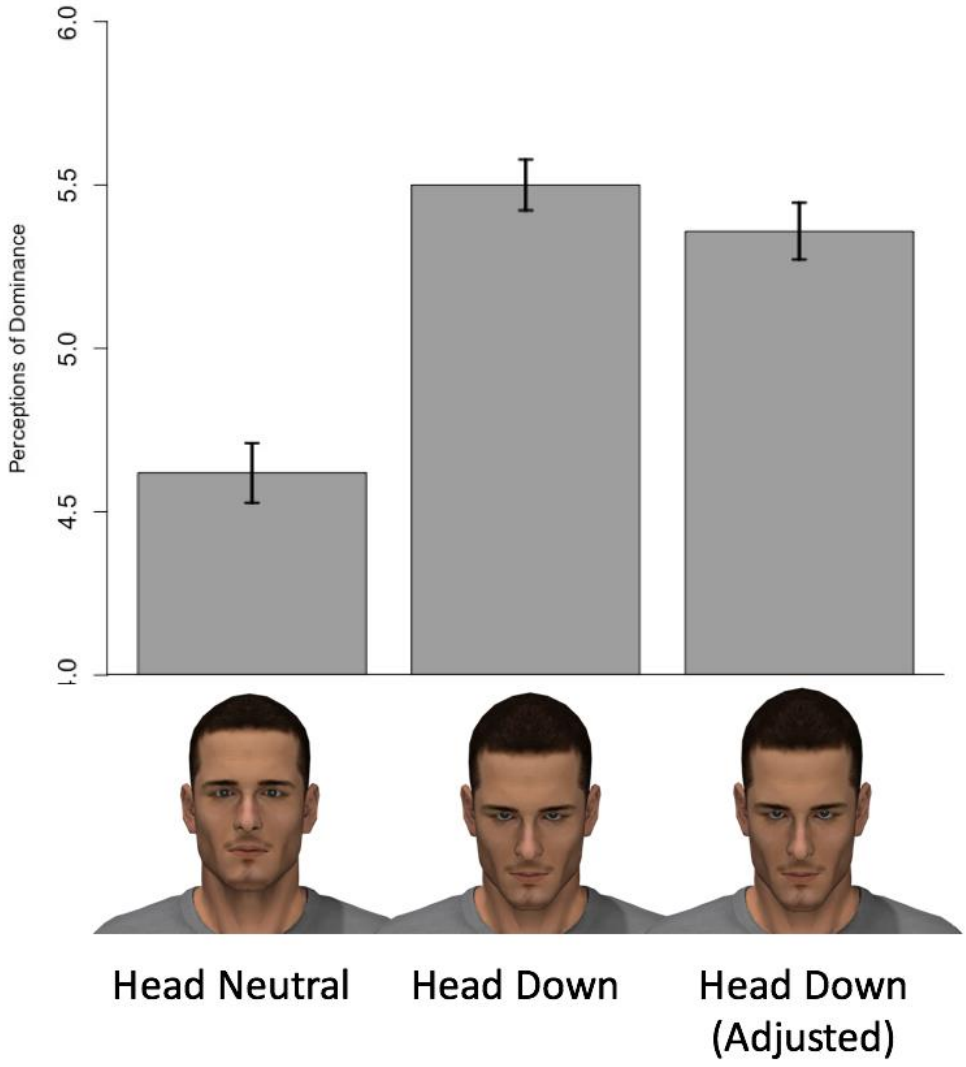

Figure S3. *Stimuli and results from Study S2*.
Note. Error bars indicate ±1SE from the mean.

Results

A one-way ANOVA uncovered a significant effect of condition on perceptions of dominance, $F(2,599)=30.55$, $p<.001$, $\eta_p^2=.09$, indicating that a downward-head tilt increased perceptions of dominance compared to a neutral head angle ($p<.001$, $d=.74$; see Figure S3). Furthermore, the target with his head tilted downward and vFWHr artificially decreased (i.e., face adjusted) was judged as significantly more dominant than the target with his head at a neutral angle, who had a larger vFHWr, $p<.001$, $d=.58$. Finally, no significant difference emerged between the two downward head-tilt conditions, $p=.74$, $d=.13$. These results suggest that perceptions of dominance are not formed on the basis of vFWHr; downward-head tilt increased perceptions of dominance even when the vFWHr was *decreased* compared to a neutral-head angle.

References

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Mignault, A., & Chaudhuri, A. (2003). The many faces of a neutral face: Head tilt and perception of dominance and emotion. *Journal of Nonverbal Behavior*, *27*(2), 111-132.

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Toscano, H., Schubert, T. W., & Giessner, S. R. (2018). Eye gaze and head posture jointly influence judgments of dominance, physical strength, and anger. *Journal of Nonverbal Behavior*, 1-25.

Tracy, J. L., & Matsumoto, D. (2008). The spontaneous expression of pride and shame: Evidence for biologically innate nonverbal displays. *Proceedings of the National Academy of Sciences*, *105*(33), 11655-11660.

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Study 1 Additional Analyses

Exploratory participant sex by head tilt interaction

An exploratory 3 (head tilt) by 2 (sex) ANOVA was conducted to assess whether the effect of head tilt on perceptions of dominance varied by participant sex. A main effect of head tilt emerged, $F(2,198) = 26.97$, $p < .001$, $\eta_p^2 = .21$, and a small main effect of participant sex emerged, $F(1,99) = 5.93$, $p = .02$, $\eta_p^2 = .06$, but no participant-sex by target interaction emerged, $F(2,198) = .17$, $p = .84$, $\eta_p^2 = .002$ (see Table S1 and Figure S4).

Table S1. *Ratings of dominance for each head tilt condition, by participant sex, Study 1.*

	Males	***Females***
Head Tilt Condition:	*M*(SD)	*M*(SD)
Down	5.27 (1.09)	5.60 (1.00)
Level	4.14 (1.29)	4.62 (1.42)
Up	4.71 (1.16)	5.16 (1.11)

Note: N = 60 males, 41 females

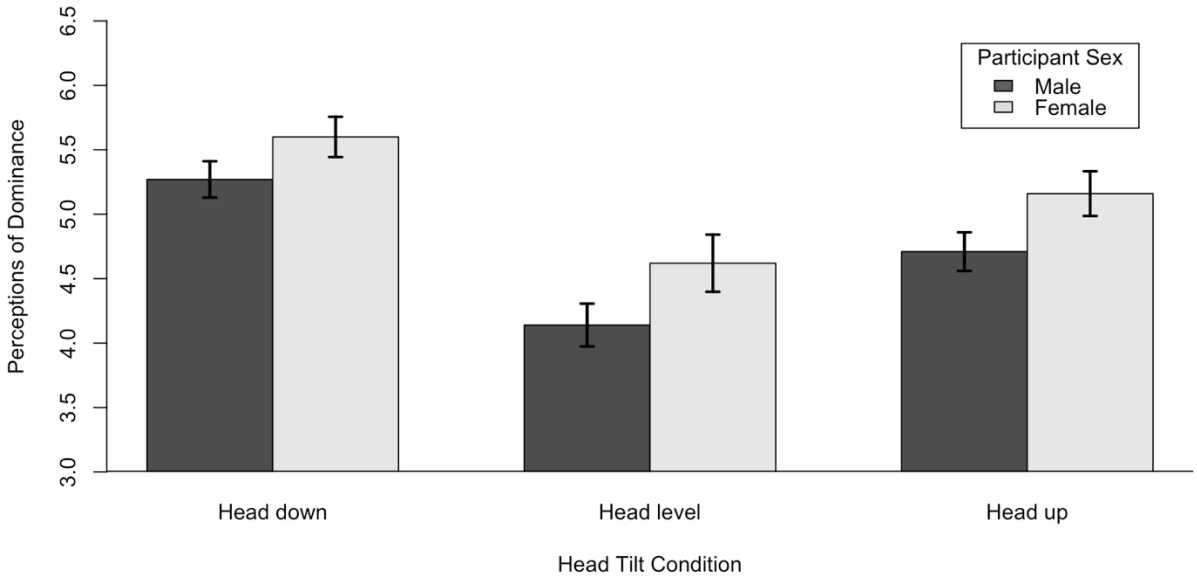


Figure S4. *Mean perceptions of dominance by head tilt condition and participant sex, Study 1.*
Note: Error bars illustrate +/- 1SE from the mean.

Study 2 Additional Analyses

Exploratory 3-way interaction between head tilt, participant sex, and target sex

We conducted an exploratory 3-way interaction between head-tilt condition, participant sex, and target sex. No interaction emerged, $F(2,558) = .81$, $p = .45$, $\eta_p^2 = .003$. However, a small 2-way interaction emerged, suggesting that participant sex moderated the main effect of head tilt on perceptions of dominance $F(2,558) = .81 = 13.67$, $p = .02$, $\eta_p^2 = .02$. Both male and female participants perceived a downwards head tilt as more dominant than a neutral head angle ($p_{male} = .001$, $d_{male} = .55$; $p_{female} < .001$, $d_{female} = 1.08$), and an upwards head tilt as more dominant than a neutral head angle ($p_{male} < .001$, $d_{male} = .58$; $p_{female} < .001$, $d_{female} = .58$), but women judged the downwards-head tilt to be more dominant than the upwards head tilt ($p_{female} = .005$, $d_{female} = .44$) whereas men did not rate these two conditions as significantly different in dominance ($p_{\text{male}} > .99$, $d_{male} = -.01$; see Figure S4). However, this interaction should be interpreted with caution; it was not predicted in our pre-registered hypotheses, and a similar exploratory analysis on the computer-generated male avatar in Study 1 yielded no such effect.

Study 4 Additional Results

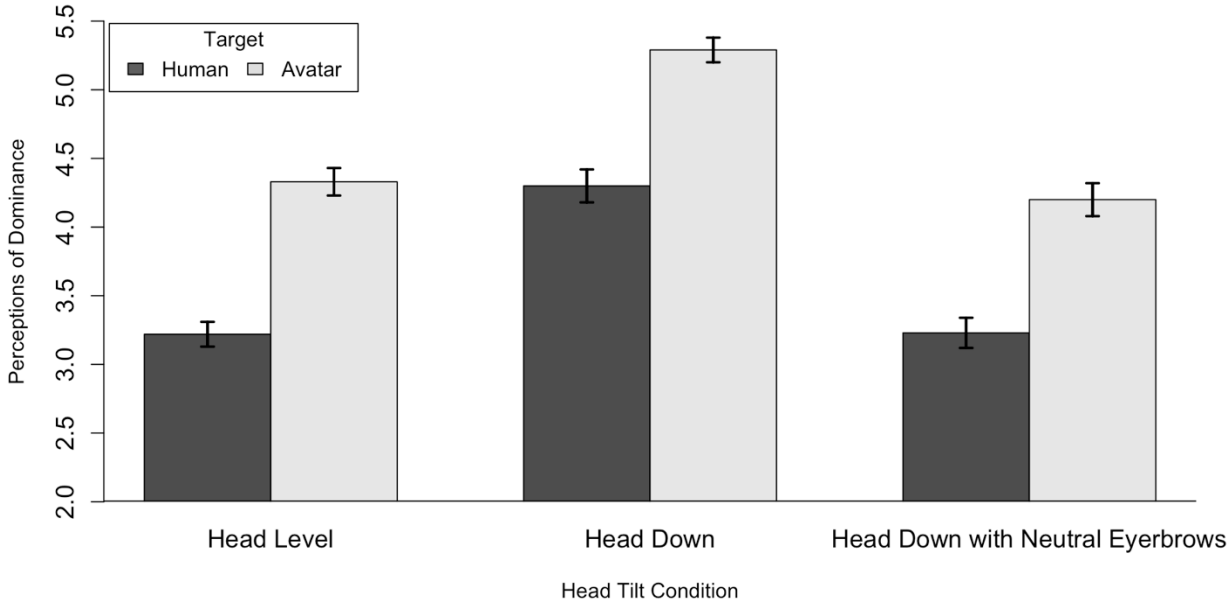


Figure S5. *Mean perceptions of dominance by head-tilt and eyebrow- alteration condition and target, Study 4.*
Note. Error bars indicate +/- 1SE from the mean.

Study 5 Additional Analyses

ANOVA Framework

A repeated-measures ANOVA was conducted to assess whether participants' eyebrow angle was more V-shaped after tilting their head down (i.e., the "a" path in our mediation model). A significant effect emerged, $F(1,117) = 44.31$, $p < .001$, $\eta_p^2 = .27$, suggesting that targets with their head tilted down had more V-shaped eyebrows compared to targets with their head at a neutral angle ($p < .001$, $d = 1.80$; see Figure S6).

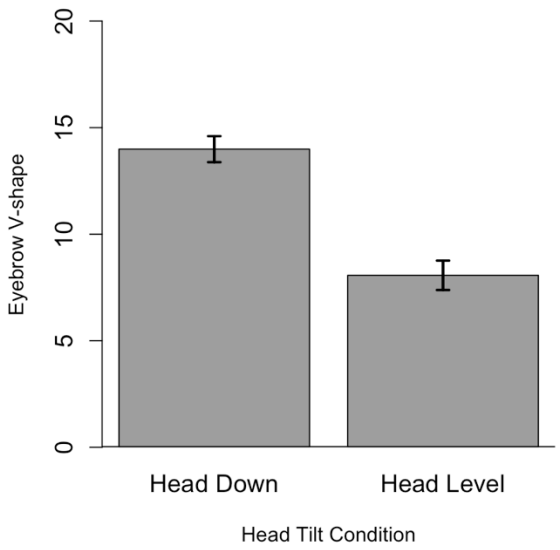


Figure S6. Eyebrow V-shape for targets with their heads level and tilted down, Study 5.

Information about additional models

As reported in Table 1, we conducted additional exploratory models controlling for target ethnicity and target gender. Due to established morphological differences between men and women, as well as morphological differences among ethnicities, we wanted to ensure that observed effects were not an artifact of these differences.

Several multilevel models predicting eyebrow V-shape from target head-tilt condition (coded 0 = head neutral, 1 = head down) and random intercepts for targets were conducted to assess the A path in our mediation model. The Bayesian Information Criterion (BIC) for each of these models is as follows:

Model	BIC
Model 1 (Baseline)	29803.90
Model 2 (Baseline + target ethnicity)	29816.95
Model 3 (Model 2 + target gender)	29821.64

Several multilevel models predicting perceived dominance from head tilt condition and eyebrow V-shape, along with random intercepts for judges, were conducted to assess the B and C pathway in our mediation model. The Bayesian Information Criterion (BIC) for each of these models is as follows:

Model	BIC
Model 1 (Baseline)	32702.62
Model 3 (Model 2 + target ethnicity)	32709.50
Model 3 (Model 3 + target gender)	32722.42

Importantly, for both the A and B pathway, the BIC increased after including target ethnicity, and after including target ethnicity and target gender, in the models.

Study S3: Manipulating eyebrow angle independently of head tilt

Like Study 4, Study S3 was designed to test the action-unit imposter account by examining whether head-tilt downward increases perceptions of dominance when the critical hypothesized cues –eyebrow angle and height – are held constant, while other upper-face features (e.g., sclera) are allowed to vary naturally. Although this study's design was similar to that of Study 4, there were several key differences. First, the stimuli in the current study were created and edited by the first author using a free software with basic editing capabilities, rather than by a trained professional using Adobe Photoshop (as was the case in Study 4). Second, we realized after completion of Study S3 that we had failed to adequately manipulate head tilt in the critical target image; as described in detail below, the head's downward angle was very minimal in the downward-tilt condition, and, as a result, the V-shape of the target's eyebrows in the unaltered head-down condition was less than two standard deviations below the mean V-shape angle observed across the 61 downward-tilted heads in Study 5. Third, only one set of stimuli, featuring one target, was used in the current study, whereas two different stimulus sets, featuring two targets, were used in Study 4. Fourth, the current study utilized a between-subjects design rather than a within-subjects design. Finally, in this brief study participants rated the dominance of a target, but there was no follow-up task asking participants to select the more dominant target from two images presented side-by-side. We therefore believe that Study 4, reported in the main manuscript, is an improved version of this study, but results are nonetheless largely similar across the studies. For pre-registration, see osf.io/tn5db.

Method

Participants and procedure

Five-hundred, sixty adults from Amazon Mechanical Turk participated in the current study; 49 of these failed an attention check and were not included in analyses, resulting in a final sample of 511 participants (56% female; age range = 18 - 73, Median = 31 years). Due to researcher error, our final sample was roughly 10% smaller than the 570 participants that would have been necessary to detect a small effect size (f = .15) in an ANOVA, based on an alpha of .016 and 80% power. However, given the smallest effect size uncovered in the current study (d = .34), alpha set at .016, and our study design (N = 511, 3 groups, between subjects), our observed power was 86%, suggesting we likely had sufficient power to detect our uncovered effects.

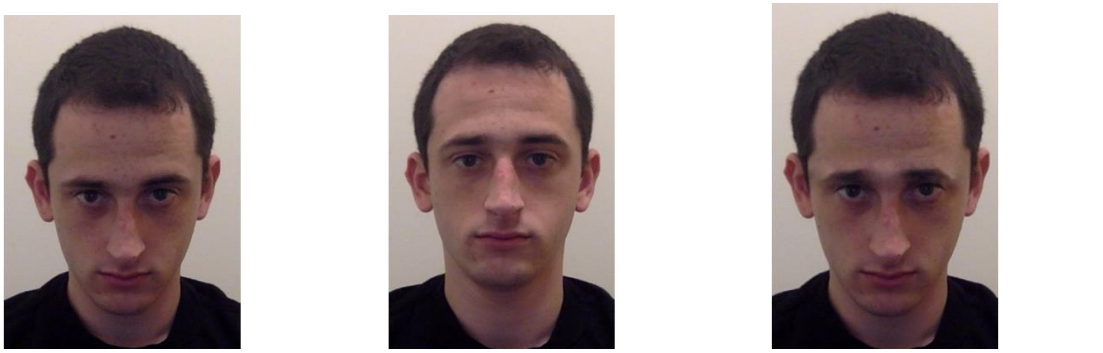
Participants were randomly assigned to view a target with his head level, tilted downward, or tilted downward with the eyebrows artificially adjusted to appear neutral; see Figure S7. Participants rated the dominance of this target using the same measure as in Studies 1-3.

Stimuli

To test whether tilting the head downward increases perceptions of dominance by altering the visual appearance of the eyebrows, we developed stimuli in which the eyebrows were artificially manipulated independently of head tilt angle. To do so, we used photographs of one human target displaying a neutral head angle, and tilting his head downward slightly. Using iPhoto, the eyebrows from the neutral head angle image were copied and used to replace the eyebrows that naturally appeared on the respective downward-head tilt photograph (see Study 4, Method, for more details on this process). Blurring and editing was performed on the artificially imposed eyebrows to make them appear more realistic. However, due to the software used and

the inexperience of the photo editor (the first author), the copied eyebrows were not gracefully integrated into the photograph, and appeared slightly different in color than the rest of the face.

In addition, after completing the study we realized that the head-tilt angle in both downward-tilt conditions was considerably subtler than that portrayed in the stimuli included in Studies 1-4, and yielded an apparent eyebrow V-shape (in the unaltered condition) that was coded as 4.50, 2.0 standard deviations below the mean of coded apparent eyebrow V-shape angle across all target participants included in the head-tilt downward condition in Study 5 (M = 13.99, SD = 4.75; see Figure S7 Figure 9). This stimulus therefore provided a much weaker manipulation of downward head tilt and, for the unaltered condition, eyebrow angle V-shape, compared to the downward-tilt stimuli used in Study 4, and was a substantially less visually apparent display of this behavior than is typical.



Head Tilt Down **Neutral** **Head Tilt + Neutral Eyebrows**

Figure S7. *Stimuli used in Study S3*

Results

A one-way ANOVA revealed a significant effect of condition on perceptions of dominance, F (2,507) = 25.18, p < .001, η_p^2 = .09. Pairwise comparisons indicated that a downward-head tilt (with no adjustment to the eyebrows) led to greater perceptions of dominance when compared to a neutral head angle (p < .001, d = .74). In contrast, the downward-head tilt with the eyebrows adjusted to appear neutral decreased perceptions of

dominance compared to the unaltered downwards-tilt condition (p = .004, d = .34), but was perceived as more dominant than the neutral head condition (p = .001, d = .40; see Figure S8). These results converge with those of Study 4 to suggest that the apparent V-shape of one's eyebrows, which is increased by a downwards head tilt, is at least partly responsible for the effect of downward-head tilt on dominance perceptions. We are hesitant to draw any additional conclusions from these results, however, given the noted limitations in the methods and stimuli used here compared to those used in Study 4.

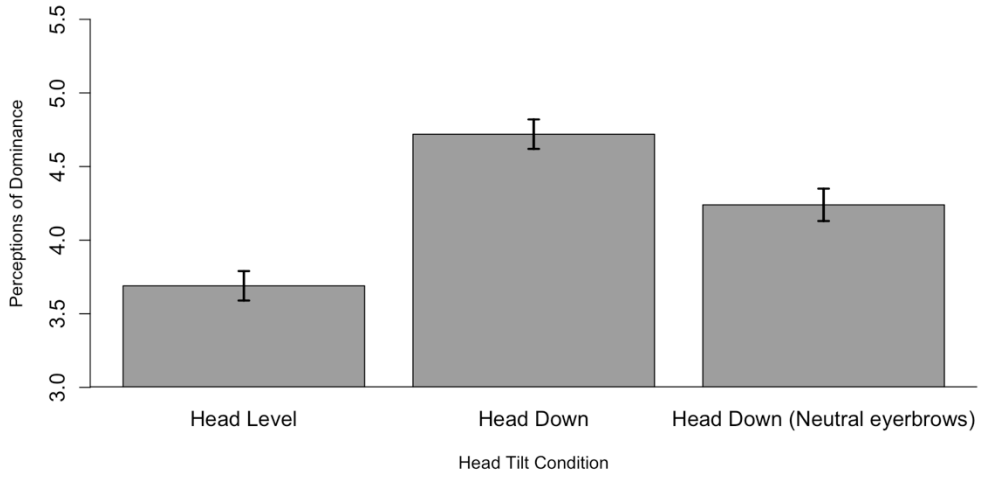


Figure S8. *Mean perceptions of dominance by head tilt and eyebrow alteration condition, Study S3.*
Note. Error bars indicate +/- 1SE from the mean.

Comparison of the Present Research and Prior Research by Lyons and Colleagues (2000)

Although prior research by Lyons and colleagues (2000) found that a downwards head tilt can increase perceptions of happiness in an expressive, slightly smiling face, possibly due to changes in the perceived curvature of the mouth, the present work goes beyond this prior research by providing the first empirical evidence that: (a) moving the head changes social perceptions of a *neutral* face, and (b) it does so *because* this movement creates the illusion of facial movement. Here, we explain in detail the ways in which our contribution is different from that of Lyons et al. (2000).

First, Lyons and colleagues (2000) addressed a different question than the present work. They sought to test whether the image of a "Noh mask" generates different perceptions of affect as a function of its tilt, and whether this effect is moderated by culture and generalizes to non-mask faces (i.e., human targets; Lyons et al., 2000). In contrast, we aimed to not only test whether head angle influences social perceptions, but, more importantly, *why* such an effect might occur (i.e., we sought to uncover the visual mechanism accounting for this effect). Although Lyons et al. (2000) speculated that tilting the head downward might influence social perceptions by changing the apparent curvature of the mouth, they did not test this explanatory account. Instead, in all three of their studies Lyons et al. (2000) manipulated head angle (of a mask face, in Studies 1 and 2, and a human face in Study 3), and assessed consequent perceptions of emotion. In contrast, the primary goal of our work was to empirically examine the mechanism accounting for the effect of head tilt on dominance perceptions; we sought to document the general effect itself in only three of our eight experiments. In five other experiments (three of which were reported in the SOM), we directly tested our Action-Unit Imposter account, by demonstrating that visually obscuring the eyebrows (Study 3) and

manipulating eyebrow angle such that it appears similar to that of an un-tilted head (Studies 4 and S3) cause the observed effect of head tilt on social perceptions to disappear. Furthermore, in Study 5 we directly measured our hypothesized mechanism (apparent eyebrow V-shape angle) and found that it does in fact mediate the relationship between head tilt and perceived dominance.

Second, Lyons et al. (2000) examined the effect of head tilt on an expressive –that is, *not* neutral—face, whereas our interest was in examining how head tilt can change perceptions of a neutral face. More specifically, the Noh mask examined by Lyons and colleagues features appearance cues associated with approximate AUs 1+2+12+25+26 (i.e., mouth open with jaw dropped, slight smile, and inner and outer portions of the eyebrows raised). This expression is a mixture of prototypical happiness and surprise displays, and when Lyons and colleagues presented these stimuli, with zero-degrees of head rotation, to participants, about 75% identified the face as happy. In their third study, which used a real human face instead of a mask, similar facial movements were displayed. In contrast, in our research we ensured that the faces we used as stimuli in all studies were neutral; this was verified by a certified FACS coder. In fact, our goal was to demonstrate that a face with no muscle movement whatsoever can take on the illusory appearance of facial muscle movement when accompanied by a downward-head tilt.

Third, Lyons et al. (2000) conducted three studies with 120 participants total (and only one study, with 40 participants, examining responses to human faces), whereas we conducted eight studies with 2,680 participants, and six of our studies tested pre-registered hypotheses. Although Lyons et al. (2000) did not report effect sizes, so we cannot calculate their observed power, each of their studies included only 10 participants per cell (based on their stated design of

a 13 (head angle) x 2 (culture) x 2 (gender) within-between-between mixed ANOVA; p. 2241), which is a notably small sample size (Simmons, Nelson, & Simonsohn, 2011), raising questions about statistical power. In sum, even if our studies are addressing a somewhat similar question to those conducted by Lyons and colleagues (though, again, we see the question itself as quite different), our work gets at these issues using a much more strongly powered design, allowing us to more precisely estimate effect sizes, and our use of pre-registration allows for greater confidence in our findings.

Fourth, our data indicate that the specific mechanism that Lyons and colleagues (2000) speculate to be responsible for their observed effect cannot, in fact, account for our observed results. That is, although Lyons et al. (2000) suggest that tilting the head downward might change the apparent curvature of the mouth, which could influence social perceptions, mouth curvature cannot account for our findings. This is because in Study 3 we occluded lower-face visibility such that participants could not see mouth curvature, yet downwards head tilt still increased perceptions of dominance. Furthermore, when upper face visibility was occluded but the lower face (including mouth) was fully visible, the previously observed effect of head tilt on perceptions of dominance no longer emerged. Given these results, illusory curvature of the mouth cannot be the mechanism underlying our observed effects.

Fifth, Lyons et al. (2000) did not examine or in any way discuss the illusory facial behavior that is the focus of our work: AU4 (eyebrow lowerer), or V-shaped eyebrows.