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

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Abstract

Research on face perception tends to focus on facial morphology and the activation of facial muscles, while ignoring any impact of head position. We raise questions for this approach, by demonstrating that head movements can dramatically shift the appearance of the face to shape social judgments, without engaging facial musculature. In five studies (total *N*=1,517) we found that when eye gaze is directed forward, tilting one's head downward (compared to a neutral angle) increased perceptions of dominance, and this effect was due to the illusory appearance of lowered and V-shaped eyebrows caused by a downward head tilt. Tilting one's head downward therefore functions as an "action-unit imposter", creating the artificial appearance of a facial action unit that has a strong effect on social perception. Social judgments about faces are therefore driven not only by facial shape and musculature, but also by movements in the face's physical foundation: the head.

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

Facial expressions – that is, changes to facial appearance caused by facial muscle activation –fundamentally shape social perceptions (Hareli, Shomrat, & Hess, 2009; Knutson, 1996; Ekman & Oster, 1979). Here, we propose and test a novel account of social perception from the face. We argue that head position plays a critical role in face perception, by causing the appearance of the face to change – paralleling the consequences of facial expressions – *without* utilizing facial musculature. Specifically, head position in the form of downward-pitch rotation, or tilt, can co-opt the psychology of facial-expression perception by creating the *visual illusion* of facial dynamics: Tilting the head downward causes the eyebrows to take on an apparent V-shape and become lowered – the same appearance cues associated with Action-Unit (AU) 4 (i.e., corrugator activation; Ekman & Friesen, 1978)—even when the face in fact remains neutral (see Figure 1). As a result, although tilting the head downward does not involve AU4, it may function as an imposter of that action unit by causing the same appearance changes.

Although prior research has not examined whether tilting the head downward causes the appearance of illusory eyebrow movement, studies have shown that actual eyebrow movement in the form of corrugator activation (i.e., AU4) increases perceptions of social rank (Keating & Bai, 1986), and that neutral faces with artificially lowered and V-shaped brows are perceived as high ranking and physically strong, threatening, or dominant (Toscano, Schubert, & Sell, 2014; Schmid-Mast & Hall, 2004; Neth & Martinez, 2009). However, these results are based on unnatural manipulations of facial features. We believe that these same changes in facial appearance *naturally* occur when the head is tilted down (assuming similar viewing conditions; Kappas, Hess, Barr, & Kleck, 1994), and shifts in head movement therefore indirectly influence social perceptions via facial appearance changes (see also Martinez, 2017). In sum, the proposed action-unit imposter hypothesis posits that when the head is tilted down, the eyebrows appear to lower and take on a V-shape (cues associated with AU4; see Figure 1), and these changes in facial appearance cause observers to form perceptions of dominance. Head tilt therefore functions as an action-unit imposter: causing the same effect as a facial-muscle movement, on an inactive face.

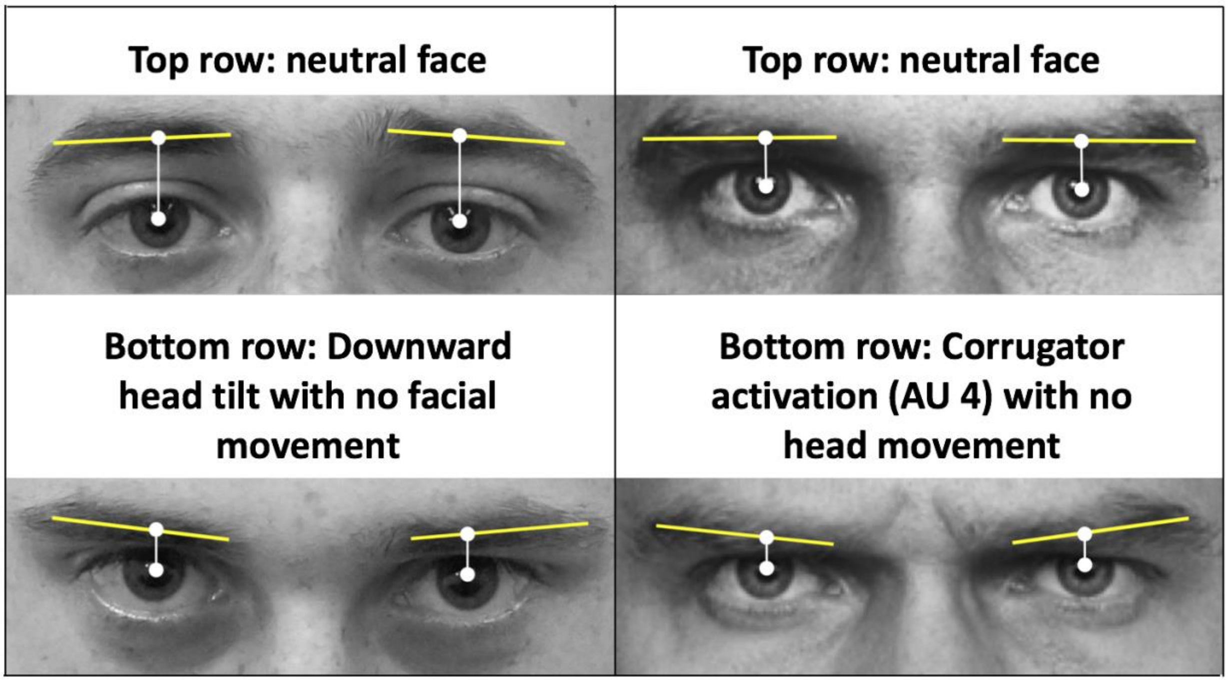


Figure 1. *Visualization of the mechanism proposed by the novel action-unit imposter account. Top: neutral head and face. Bottom: downward-head tilt (left), and activation of AU4 (right). Both movements create the appearance of a V-shape and lowering of the eyebrows.*[1]

Prior researchers have suggested that head movements contribute to perceptions of dominance, but the direction and mechanism underlying this effect remain elusive. Several scholars have suggested that tilting the head downward is a closed and contracted nonverbal

[1]Although downward-head tilt and AU4 both cause the appearance of eyebrow lowering and V-shape, the behaviors are distinguishable; AU4 can cause bulging and wrinkles above the nose, and downward-head tilt can cause increased sclera below the iris.

movement that makes individuals appear smaller (Mignault & Chaudhuri, 2003; Rule, Adams Jr, Ambady, & Freeman, 2012), thereby decreasing perceptions of dominance (Marsh, Yu, Schechter, & Blair, 2009; Blaker & van Vugt, 2014). Similarly, Lyons and colleagues (2000) suggested that tilting the head down might alter the apparent curvature of the mouth, increasing the extent to which a slightly smiling target is perceived as happy, an emotion that communicates warmth and affiliation and should therefore decrease perceptions of dominance (Witkower, Tracy, Cheng, & Henrich, 2018). Yet others have suggested exactly the opposite: that a downwards head tilt *increases* perceptions of dominance, by increasing the visible facial width-to-height ratio (vFWHr; Hehman, Leitner, & Gaertner, 2013) – a holistic facial metric associated with aggression and intimidation (Geniole, Denson, Dixson, Carré, & McCormick, 2015; but see Kosinski, 2017).

Our AU-imposter account, like the vFWHr hypothesis, and contrary to both the closed-and-contracted and mouth-curvature hypotheses, suggests that downwards-head tilt should *increase* perceptions of dominance from a neutral (i.e., completely inactive) face. Critically, however, our account offers a novel visual mechanism to explain this effect. In eight studies (three reported in the SOM), we test our AU-imposter account and provide the first empirical evidence that head movements can shape social judgments by creating the illusion of facial action and thereby altering the appearance of a neutral (i.e., inactive) face.

Study 1

Method

Participants and procedure. One hundred, twenty-five adults were recruited from Amazon Mechanical Turk to participate in the current within-subjects study; 24 of these failed an attention check and were not included in analyses, resulting in a final sample of 101 participants

(41% female; age range = 19- 62, Median = 30 years). A power analysis indicated that our within-subjects design would require 55 participants to detect a moderate effect of head tilt angle on perceptions of dominance (f = .20) with 80% power (alpha = .016 for anticipated Bonferroni correction with 3 groups, correlation among repeated measures = .5, no nonsphericity correction). However, given our goal of seeking to uncover a robust effect to help resolve the conflicting predictions offered by extant theoretical accounts, we elected to roughly double that *N*. Participants viewed three human-like male avatars in a randomized order and judged the dominance of each.

Materials and measures

Stimuli. Avatars were generated with Poser Pro (2014; see Figure 2, top row), to ensure precise manipulations of targets' head angle while preventing any incidental facial or body movements; all targets displayed neutral facial expressions (i.e., no facial muscle activation). Each target was portrayed either tilting his head upward ten degrees, holding his head at a neutral angle (i.e., 0 degrees), or tilting his head downward ten degrees. Eye gaze was directed towards observers in all stimuli, because numerous studies have shown that a head tilt downward combined with eye gaze averted away from observers leads to perceptions of shame and submissiveness, essentially the opposite of dominance (e.g., Keltner, 1995; Tracy, Robins, & Schriber, 2009; Tracy & Robins, 2008; Shariff & Tracy, 2009). Furthermore, we validated this assumption in a pre-registered study (Study S1 in SOM-R), which found that perceptions of dominance from a downward head tilt emerge only when eye gaze is directed toward observers (also see Toscano, Schubert, & Giessner, 2018).

Figure 2. *Stimuli used in Study 1 (top row) and Study 2 (middle and bottom rows).*
Note. Pictured from left to right: downward head tilt, neutral head angle, upward head tilt. In all images, targets posed neutral facial expressions (i.e., no facial muscle movement).

Perceptions of dominance. Participants judged the dominance of each target using an abbreviated version of the Dominance scale ($\overline{\alpha}$ = .88; Cheng, Tracy, & Henrich, 2010), a validated measure of *dominance*, defined as the use of intimidation or threat to influence others. This scale has been found to predict both perceived and actual influence (in the form of persuasion; Cheng, Tracy, Foulsham, Kingstone, & Henrich, 2013). The four items constituting the abbreviated scale (chosen because they had the highest factor loadings on a dominance factor in initial studies validating the overall scale; see Cheng et al., 2010, SOM) were: “This person would enjoy having control over others”, “This person would be willing to use aggressive tactics to get their way”, “This person would often try to get his way regardless of what people may want", and "This person would try to control others rather than permit them to control him." Participants rated their agreement with each statement, for each target, on a scale ranging from 1 (*not at all*) to 7 (*very much*). In all studies we included additional exploratory items but our primary hypotheses were focused on perceptions of dominance so only those results are presented (see osf.io/tn5db). For the full set of measures included, please contact the first author.

Results

Our AU-imposter hypothesis predicts that the downward-head tilting target should be perceived as more dominant than the upward-tilting or neutral targets, because only the downward head tilt mimics the activation of AU4. The visible FWHr hypothesis predicts that both downward and upward head tilt should increase perceived dominance, because both angles make the face appear wider relative to its height. The closed-and-contracted hypothesis predicts that downward head tilt, a contracted behavior, should *decrease* perceived dominance, whereas upward tilt, an expansive behavior, should increase it. Similarly, the mouth-curvature hypothesis indirectly predicts that downwards head tilt should decrease perceptions of dominance, by virtue of increasing perceptions of happiness – an emotion expression that communicates warmth and affiliation.

In all studies Bonferroni corrected pairwise comparisons were conducted whenever more than two conditions were present. Effect size estimates for repeated measures were calculated based on Morris and DeShon (2008). A one-way repeated measures ANOVA uncovered a significant effect of head tilt on perceptions of dominance, $F(2,200) = 28.99$, $p < .001$, $\eta_p^2 = .23$, indicating that a downward head tilt was judged to be significantly more dominant than a neutral and an upwards tilt (see Figure 3; *p*s < .001, *ds* = .79 and .39, respectively). In addition, an upwards head tilt was judged to be significantly more dominant than a neutral head angle, but the magnitude of this effect was less than half the size of that of downward tilt vs. neutral ($p < .001$, $d = .37$). An exploratory 3 (head tilt) by 2 (gender) ANOVA was conducted to assess whether the effect of head tilt on perceptions of dominance varied by participant gender. No interaction emerged, $F(2,198) = .17$, $p = .84$, $\eta_p^2 = .002$.

Discussion

Consistent with the AU-imposter and vFWHr hypotheses, but inconsistent with the closed-and-contracted and mouth-curvature hypotheses, downward-head tilt *increased* perceptions of dominance when compared to neutral-head angle. Downwards-head tilt was also perceived as more dominant than upward-head tilt, consistent with the AU-imposter account but not with the vFWHr account.

Study 2

Method

Study 2 was a preregistered attempt to replicate the results of Study 1 using human (rather than computer-generated avatar) targets of both genders, and a between-subjects rather than within-subjects design (see osf.io/tn5db).

Participants and procedure. Six hundred, seventeen adults from Amazon Mechanical Turk participated in the current between-subjects study; 47 of these failed an attention check and were not included in analyses, resulting in a final sample of 570 participants (53% female; age range = 17- 74, Median = 31 years). This exceeded the 524 participants that would be necessary to uncover an effect size of $f = .25$ in a 3 X 2 between-subject ANOVA, based on an alpha of .016 (anticipating a Bonferroni correction for 3 groups) and 90% power.

In a 3 (head tilt: down vs. level vs. up) x 2 (target sex: male vs. female) between-subjects design, participants viewed the head and neck of a human target portraying a neutral facial expression while holding his or her head either at a neutral angle, tilted upward, or tilted downward, always with gaze directed toward the viewer (see Figure 2, middle and bottom rows). Participants were randomly assigned to view one of six single targets and indicate how dominant they perceived him or her to be, using the same measure of dominance as in Study 1.

Stimuli. A male and a female Caucasian actor, both in their mid 20s, posed the three head tilt positions following instructions from the first author. Images were verified by a research consultant who is a certified expert in the Facial Action Coding System (FACS; Ekman & Friesen, 1978) as displaying the intended head angle (up, down, or level) with eye gaze directed toward the camera and no additional facial muscle behavior.

Results

Supporting our pre-registered hypotheses, a 3 (head tilt) x 2 (target sex) ANOVA uncovered the predicted main effect of head tilt on perceptions of dominance, $F(2, 564) = 34.51$, $p < .001$, $\eta_p^2 = .11$, suggesting that a downward-head tilt was judged to be significantly more dominant than a neutral-head angle and an upward-head tilt (ps $\leq .029$, ds = .82 and .23, respectively; see Figure 3). An upward-head tilt was also judged to be significantly more dominant than a neutral-head angle ($p < .001$, $d = .41$). A main effect of target sex also emerged, $F(1, 564) = 20.81$, $p < .001$, $\eta_p^2 = .04$, suggesting that the male target was judged to be significantly more dominant than the female target, $p < .001$, $d = .32$. However, no target sex by head tilt interaction emerged, $F(2, 564) = .033$, $p = .97$, $\eta_p^2 < .001$, suggesting that the magnitude of the head tilt effects did not vary by gender of the displayer (for additional exploratory interaction models, see SOM-U). Overall, these results replicate those of Study 1 and indicate that the downward-head-tilt effect is not restricted to a non-human avatar and generalizes across target gender.

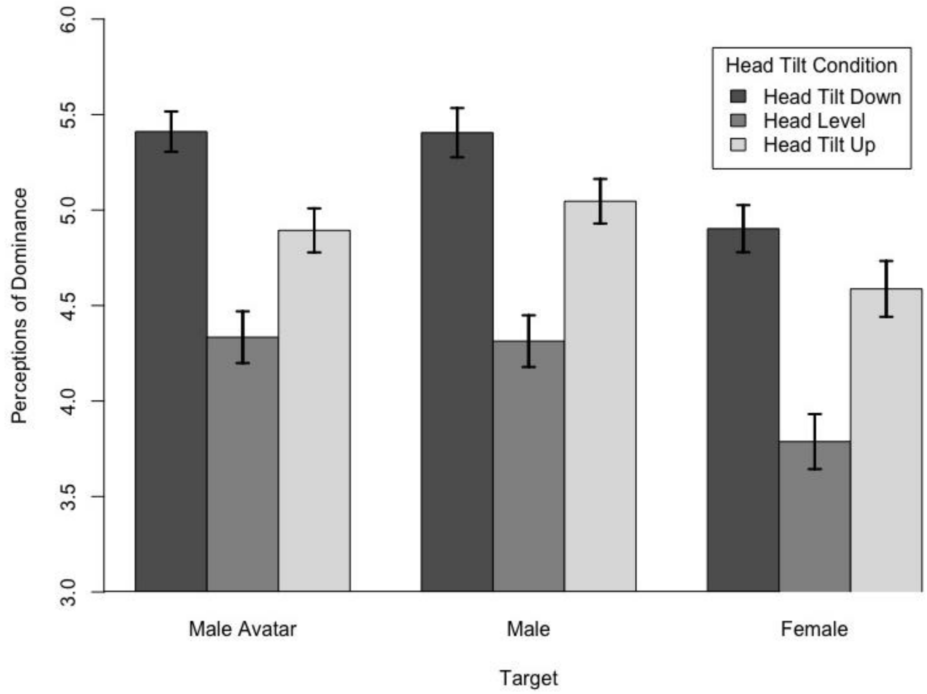


Figure 3. Mean perceptions of dominance by head tilt and target gender, Study 1 (bars on left) and Study 2 (bars in the middle and on right). *Note.* Error bars indicate +/- 1SE from the mean.

Study 3

Our results thus far support our AU-imposter hypothesis and the alternative vFWHr hypothesis; our next studies pitted these against each other, while also providing stringent tests of the AU-imposter account. This account leads to several narrower predictions not shared with the vFWHr hypothesis. First, the upper face (i.e., narrow band from the cheekbones to the brow ridge, excluding the forehead and mouth) alone should be *sufficient* to communicate dominance from a downwards-head tilt, given that the critical cues lie in the eyebrows and eyes. We therefore predicted that a downwards-head tilt would increase perceptions of dominance even when participants viewed this narrow band in isolation—and, importantly, were prevented from seeing that the target's head was tilted. In contrast, the vFWHr hypothesis predicts exactly the opposite; a face's height and width can be perceived only by observing the head's height and width, so the upper face in isolation should not increase dominance perceptions even if the head is tilted downward.

Second, the AU-imposter hypothesis suggests that the upper face is *necessary* for a downwards-head tilt to influence perceptions of dominance, given that the critical cue – changed eyebrow appearance—lies in in that narrow band. We therefore further predicted that the effect of a downwards-head tilt on perceptions of dominance would not emerge if the upper face were visually occluded, even if the head's downward tilt was still visible. Study 3, preregistered at osf.io/tn5db, thus provides a stringent test of the AU-imposter account by testing two conservative predictions derived from it and pitting it against the vFWHr account.

Method

Participants and procedure. Two-hundred, twenty-seven adults from Amazon Mechanical Turk participated in the current study; 18 of these failed an attention check and were not included in analyses, resulting in a final sample of 209 participants (58% female; age range = 18 - 69, Median = 32 years). This exceeded the 171 participants that would be necessary to uncover an effect size of (f = .25) in a 3 X 2 between-subject ANOVA, based on an alpha of .05 and 90% power. Because this was our first direct test of the AU-imposter hypothesis, we sought to increase power to reduce the likelihood of Type I errors.

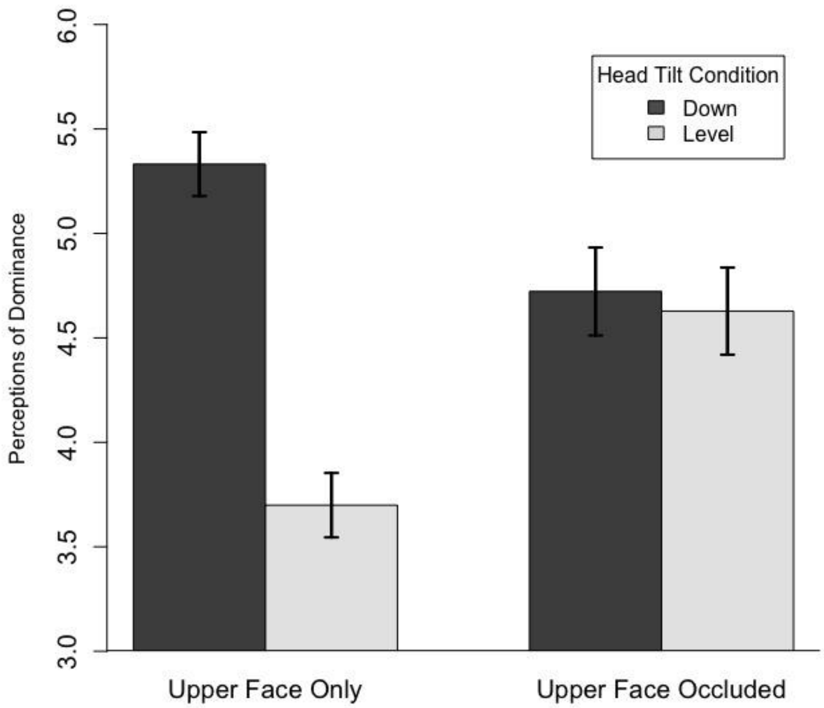
Participants were randomly assigned to one of four conditions in which they viewed a single stimulus image and indicated their perceptions of dominance using the same measure as in previous studies.

Stimuli. In this 2 (head tilt: down vs. level) x 2 (stimulus type: upper-face only vs. upper-face occluded) between-subjects design, participants viewed the avatar target from Study 1 with his head either at a neutral angle or tilted downward ten degrees; these stimuli also varied in whether they consisted of the upper face only (i.e., narrow band consisting of eyes, eyebrows, bridge of nose), or the whole head with the upper face occluded (see Figure 4).

Figure 4. *Stimuli used in Study 3. Top row: "Upper face only" condition; bottom row: "Upper face occluded" condition. Left column: neutral head angle; right column: head-tilt downward.*

Results

A 2 (head tilt: downward versus level) x 2 (stimulus type: upper face only vs. upper face occluded) ANOVA uncovered a main effect of head tilt, $F(1,205) = 21.74$, $p < .001$, $\eta_p^2 = .10$, which was qualified by a head tilt by stimulus type interaction, $F(1, 205) = 17.26$, $p < .001$, $\eta_p^2 = .08$; see Figure 5).



Stimulus Condition

Figure 5. *Mean perceptions of dominance by head tilt and face visibility conditions, Study 3.*
Note. Error bars indicate +/- 1SE from the mean.

Examining the effect of head tilt separately for each stimulus type revealed that, consistent with our preregistered hypotheses, when participants viewed the upper face in isolation, a large effect of head tilt emerged on perceptions of dominance, $F(1,112) = 38.46$, $p < .001$, $\eta_p^2 = .26$, $d = 1.17$, indicating that a downwards head tilt was perceived as significantly more dominant than a neutral head angle even when only the upper face was visible (see Figure 5). Also consistent with our hypotheses, when the upper face was occluded, no effect of head tilt emerged on dominance perceptions, $p = .71$, $d = .07$. (It is also noteworthy that an unpredicted simple effect of facial occlusion on dominance emerged within the neutral-head tilt condition, $p = .003$, $d = .37$. Importantly, this effect is not relevant to the question of why head tilt downward increases dominance perceptions; we suspect it to be due to certain masculine facial features that are only apparent when the full face is visible, such as prominent cheekbones and facial hair.)

Discussion

These results suggest that the upper face is both necessary and sufficient for a downward-head tilt to influence perceptions of dominance. This finding is inconsistent with the vFWHr account; even when participants could not perceive vFWHr in the upper-face-only condition, they judged the target as more dominant when his head was tilted downward. We also verified this conclusion in Study S2, reported in the SOM-R: When artificially reducing vFWHr by elongating the face of a target tilting his head downward, greater dominance perceptions continued to emerge, even though vFWHr was smaller than in the neutral condition. The results of Study 3 are also inconsistent with prior research highlighting the importance of the mouth in these perceptions (Lyons et al., 2000); here, downwards-head tilt influenced perceptions of dominance even when mouth curvature was not visible, and did not affect perceptions of dominance when the mouth was visible but the upper face was not. Together, these findings are consistent with our hypothesis that tilting one's head downward mimics the activation of facial muscles to create the illusory appearance of AU4, consequently increasing perceptions of dominance.

Study 4

Although the results of Study 3 are consistent with the AU-imposter hypothesis and not other extant hypotheses, they leave open several questions. In particular, the observed effects might be attributable to alternative appearance changes to the upper face caused by downward-head tilt, such as increased sclera below the iris, or heightened salience of directed-eye gaze when the lower face is hidden. To test our hypothesis that dominance perceptions form from the illusory appearance of lowered and V-shaped eyebrows—cues associated with AU4 rather than these other changes—in Study 4 (preregistered at osf.io/tn5db) we examined whether the effect would emerge when the critical hypothesized cues were held constant while other upper-face features (e.g., sclera) were allowed to vary naturally. If tilting the head downward causes increased perceptions of dominance by acting as an action-unit imposter and *not* by virtue of other changes that naturally co-occur, the effect should *not* emerge when eyebrows are held constant while the head is tilted downward. In this study we also conducted a second test of this hypothesis using a different experimental design and a new measure of dominance perceptions.

Method

Participants and procedure. Two-hundred, forty-one adults from Amazon Mechanical Turk participated in the current study; 51 of these failed an attention check and were not included in analyses, resulting in a final sample of 190 participants (58% female; age range = 19 - 74, Median = 34 years). This sample exceeded the 70 participants that would be necessary to uncover a moderate sized effect ($f = .25$) in a 3 X 2 repeated-measures ANOVA, based on an alpha of .016, 80% power, no correlation among repeated measures, and no correction for sphericity.

In this two-part study, participants first viewed six stimuli (i.e., two different targets displaying head level, head tilted down, and head tilted down with eyebrows artificially adjusted to appear neutral; see Figure 6) in a random order and rated the dominance of each using the same measure as in previous studies.

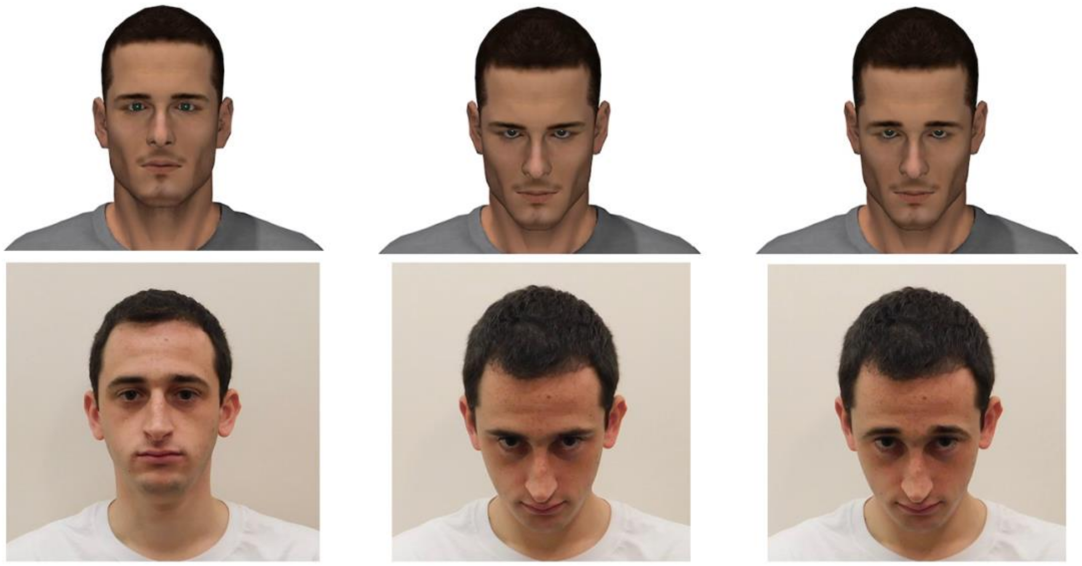


Figure 6. *Stimuli used in Study 4. Avatar (top row) and human (bottom row) displaying a neutral head angle (left column), head tilted downward (middle column), and head tilted downward with eyebrows copied and replaced from the neutral-head tilt condition (right column).*

Second, participants were shown two of these images side-by-side and asked to select the image of the target who is "likely to be a leader because he is willing to use aggression and intimidation to get his way." This item was pre-tested for its validity as a single-item measure of perceived dominance; results suggested that it successfully captured perceptions of dominance from full-body nonverbal displays previously demonstrated to communicate dominance (Witkower et al., 2018; Witkower, Hill, Pun, Baron, & Tracy, 2018). Participants completed this forced-choice item for all possible comparisons within each target (i.e., six times total). This secondary procedure was included to test whether similar results would emerge when participants directly compared images, responded in a forced-choice manner, and used a different measure of perceived dominance, allowing us to examine whether results generalize across perception assessment methods and analytic approach (i.e., using continuous rating scales as well as a forced-choice method).

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 two targets (a human displayer and an avatar) displaying: (1) a neutral head angle and (2) tilting his head downward roughly 10 degrees. Using Adobe Photoshop, the eyebrows from the neutral head angle version of both targets were copied and used to replace the eyebrows that naturally appeared on the respective downward head tilt photographs of both targets. The resulting downward-head tilt stimuli included all features that naturally emerge with a downwards head tilt (e.g., increased sclera) with the exception of the eyebrows, which were instead identical in appearance to those in the neutral-head tilt condition (see Figure 6).

Results

To determine whether it would be appropriate to aggregate analyses across targets, we conducted a 3 (condition) X 2 (target: human vs. avatar) within-subjects ANOVA on perceptions of dominance using the continuous rating scale, and found no evidence of a target by condition interaction, F (2,378) = .53, p = .59, η_p^2 = .003. We therefore collapsed across targets in remaining analyses. Consistent with our pre-registered hypothesis, a one-way ANOVA revealed a significant effect of condition on perceptions of dominance (using the 7-point scale), F (2,378) = 91.79, p < .001, η_p^2 = .33. Pairwise comparisons indicated that a downward head tilt (with no adjustment to the eyebrows) led to greater perceptions of dominance than a neutral head angle (p < .01, d = .80). In contrast, a downward-head tilt with the eyebrows adjusted to appear neutral did not increase perceptions of dominance compared to a neutral-head angle (p > .99, d = -.06). This pattern of results was consistent for both targets: human: d = .75 and .01, ps < .001 and >.99, respectively; and avatar: d = .73 and -.08, ps < .001 and .80, respectively. Finally, downward-head tilt with eyebrows adjusted was perceived as less dominant than downward-head tilt with no adjustment to the eyebrows ($p < .001$, $d = .90$). Again, this effect emerged for the human target ($d = .68$, $p < .001$) and the avatar ($d = .77$, $p < .001$). These results suggest that a downward-head tilt increases perceptions of dominance only if the eyebrows are permitted to take on a V-shape appearance (see Figure 7). (also see SOM-U, Study S3)

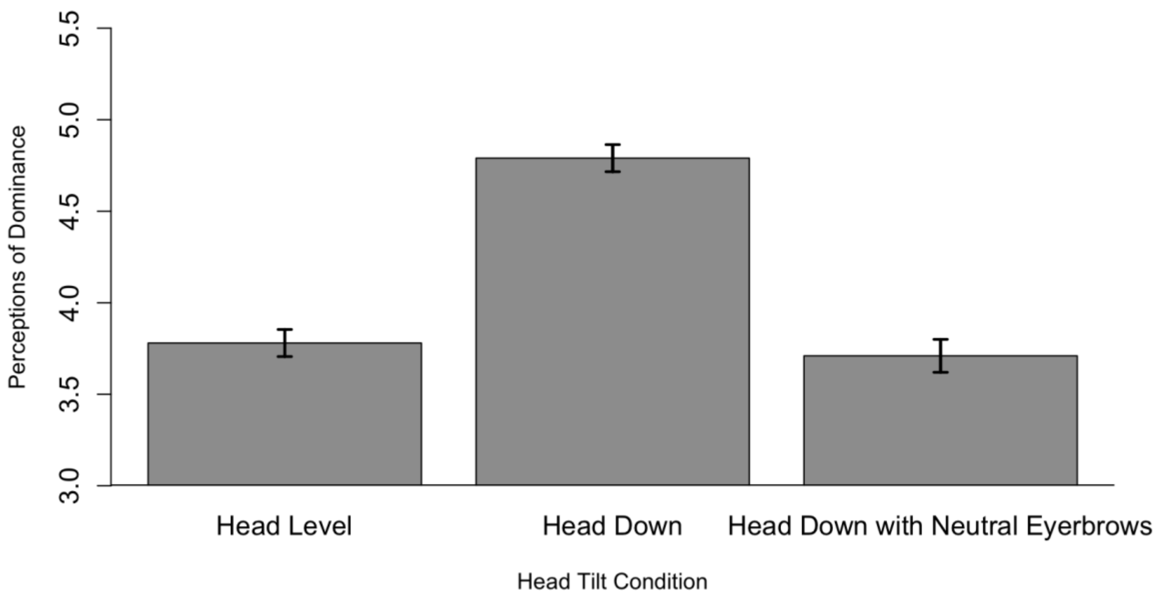


Figure 7. *Mean perceptions of dominance by head tilt and eyebrow alteration condition, Study 4. Mean ratings for each target are presented in Figure S5. Note.* Error bars indicate +/- 1SE from the mean.

Turning to the forced-choice response item, a series of binomial tests (with chance set at 50% for the two response options) were conducted to determine which condition led to the greatest perceptions of dominance. Overall, targets displaying a downward-head tilt without their eyebrows adjusted were selected as more dominant than those displaying a neutral-head angle (76%, $p < .001$, 95% CI: [71% - 80%]). In contrast, targets with downward-head tilt and eyebrows adjusted were selected as dominant *less* often than those with a neutral-head angle

(23%, $p < .001$, 95% CI: [19% - 28%]), and less often than targets with the head tilted downward and naturally shifting eyebrow appearance (8%, $p < .001$, 95% CI: [06% - 11%]). These results parallel those from the first part of the study based on continuous ratings, and again support our hypothesis that a downward-head tilt increases perceptions of dominance only if the eyebrows are permitted to naturally take on an apparent V-shape. Although we did not expect to observe a decrease in dominance perceptions in the artificially manipulated eyebrow condition compared to neutral, this result might be due to participants misperceiving a different muscle activation (i.e., Frontalis, Pars Medialis; AU1—a movement associated with sadness; Ekman & Friesen, 1978; Olszanowski et al., 2014; Langner et al., 2010), which did not actually occur, when directly comparing the two head-tilt conditions right next to each other.

Study 5

Studies 3 and 4 produced robust and convergent results, but used artificially manipulated head and facial features. Although experimental manipulations are often considered the best way to test hypotheses about mediating mechanisms (Spencer, Zanna, & Fong, 2005)—in this case, that head-tilt downward causes the illusory appearance of lowered and V-shaped eyebrows, which in turn increases perceptions of dominance—both studies utilized somewhat unnatural or partially occluded stimuli, which might have contributed to results. Study 5 tested our hypothesized mediational model using unaltered images.

Method

We manipulated head tilt in a diverse sample of targets and tested: (a) whether downward-head tilt led to the appearance of a more V-shaped brow compared to a neutral-head angle, (b) whether downward-head tilt increased perceptions of dominance compared to a neutral angle, and (c) whether the latter effect was mediated by apparent eyebrow angle.

Participants and procedure. In the current yoked design, we recruited two samples of participants: *targets* who were photographed posing neutral expressions while tilting their heads downward and holding them at a neutral angle, and *judges* who viewed photos of targets and rated perceptions of dominance. One-hundred, forty undergraduates from the University of British Columbia participated as targets. Upon entering the lab, targets were seated in a chair facing a Nikon Coolpix B500 HD camera mounted on a tripod. The tripod was adjusted so that the camera was at equal height with each target's eye-level. All photographs were taken in the same room with targets seated in the same chair, using the same camera and under the same lighting conditions. Targets were asked to sit up straight with their back against the back of the chair while two photos were taken. First, they were asked to maintain a neutral facial expression while looking into the camera. If they failed to maintain a neutral expression, research assistants prompted them to do so. Next, targets were asked to tilt their head downward between 10 and 15 degrees while maintaining a neutral expression and looking into the camera. Targets were provided with visual examples of head pitch rotation (with a neutral expression) to help clarify the instructions when necessary. Targets who failed to maintain a neutral expression in the upper face and lower face (a considerably large number; maintaining a completely neutral face is fairly difficult for untrained participants), had an eyebrow or part of the face that was not visible in photographs, or failed to follow instructions (i.e., tilted their head upward in the neutral condition) were excluded.

After these exclusions, we were left with 61 targets displaying two head angles (122 photographs in total); these individuals varied in ethnicity (15 White/Caucasian, 36 East Asian, 2 Hispanic/Latino, 2 Middle Eastern, 6 other/unknown/missing) and gender (73% female).

Importantly, all exclusions were made before we recruited or showed images to judges, and before we coded the eyebrow angles of images (see below).

Next, 451 judges were recruited from Amazon Mechanical Turk; 65 of these failed an attention check and were not included in analyses, resulting in a final sample of 386 judge participants (58% female; age range = 19 - 74, Median = 34 years). Judges were shown 20 randomly selected images from the set of 122 photos featuring the 61 targets either tilting their head down or holding their head at a neutral angle. Judges indicated how dominant each target was using the single item that was used and validated in Study 4: “This person is likely to be a leader because he/she is willing to use aggression and intimidation to get his/her way.” We elected to use the single item measure, and recruit a large sample of judges but show each judge only 20 of the 221 images, to reduce the amount of time necessary to complete the study and thereby avoid data quality degradation while still maximizing power.

Eyebrow Angle Coding. Four research assistants coded the apparent angle of each eyebrow in photos of all targets using a novel coding procedure that produced high interrater reliability (left eyebrow alpha = .97, right eyebrow alpha = .96). Images were presented on separate slides in Microsoft PowerPoint after being cropped for equal sizing across all targets. For each face, two horizontal line objects were created (line height = 0.00; line width = 0.50”, line thickness = 1pt). Eyebrow coders were asked to adjust these lines to cover the eyebrows, and rotate each line until it accurately characterized each eyebrow (see Figure 8) “as if it was a line-of-best-fit characterizing a scatterplot.” Coders were permitted to alter the visual qualities of the target image to help isolate the eyebrows if necessary (e.g., brightness, contrast), but not the shape or size of the image.

Given that our hypotheses pertained to the appearance cues associated with corrugator activation (i.e., AU4), the medial and central parts of the eyebrow were our primary focus; in some images, the lateral parts of the eyebrow (i.e., the "tail") was at a different angle from the medial part, but in such cases coders were instructed to ignore the tail and instead focus on fitting the line to the thickest part (i.e., main portion) of the eyebrow. The final angle of each eyebrow was measured by the deviation in the angle from the initial horizontal line. Angles of the left and right eyebrow were highly correlated in both conditions (r = -.75, p < .001, 95%CI: [-.82 to -.66]), so we assessed brow V-shape by averaging both eyebrows' angle after multiplying the apparent right eyebrow (i.e., perceiver's perspective) by negative 1, such that higher numbers indicate greater downward angle of both brows, or perceived V-shape. The distribution of eyebrow angle for each head tilt condition is presented in Figure 9.

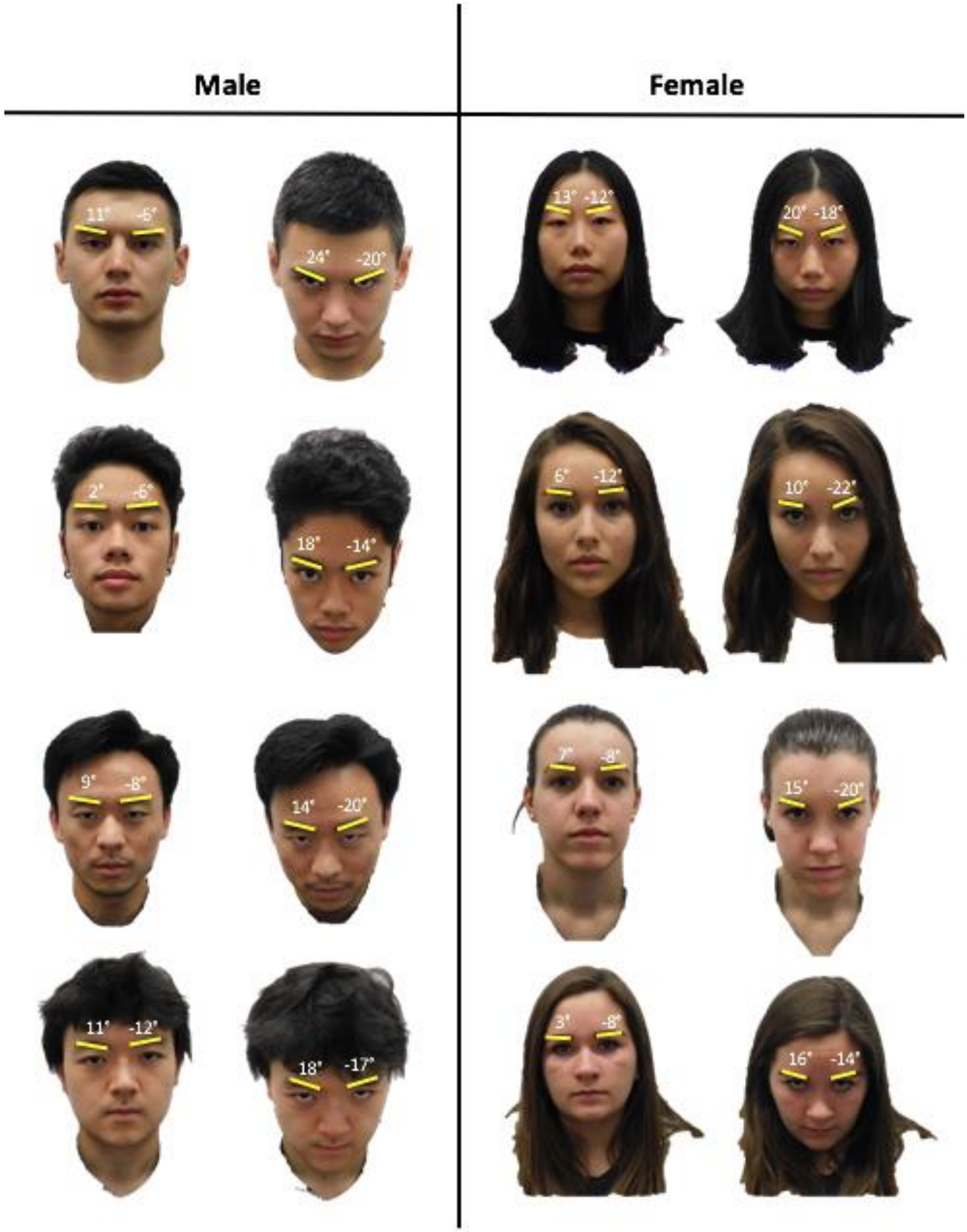


Figure 8. *Examples of eyebrow-angle coded faces, Study 5.*

Results

Several multilevel models were constructed to test the indirect effect of head tilt on perceived dominance via changes to eyebrow V-shape (see Figure 10). First, a multilevel model predicting eyebrow V-shape from target head-tilt condition (coded 0 = head neutral, 1 = head down) and random intercepts for targets indicated that targets who portrayed a downwards-head tilt had a greater V-shape in their eyebrow angle, $b = 5.92$, $t = 160.53$, $p < .001$, 95% CI: [5.84 to 5.99] (for mean eyebrow V-shape in each head-tilt condition, see Figure 9). This effect remained robust after including random slopes for head-tilt condition and controlling for target ethnicity and gender (see Table 1).

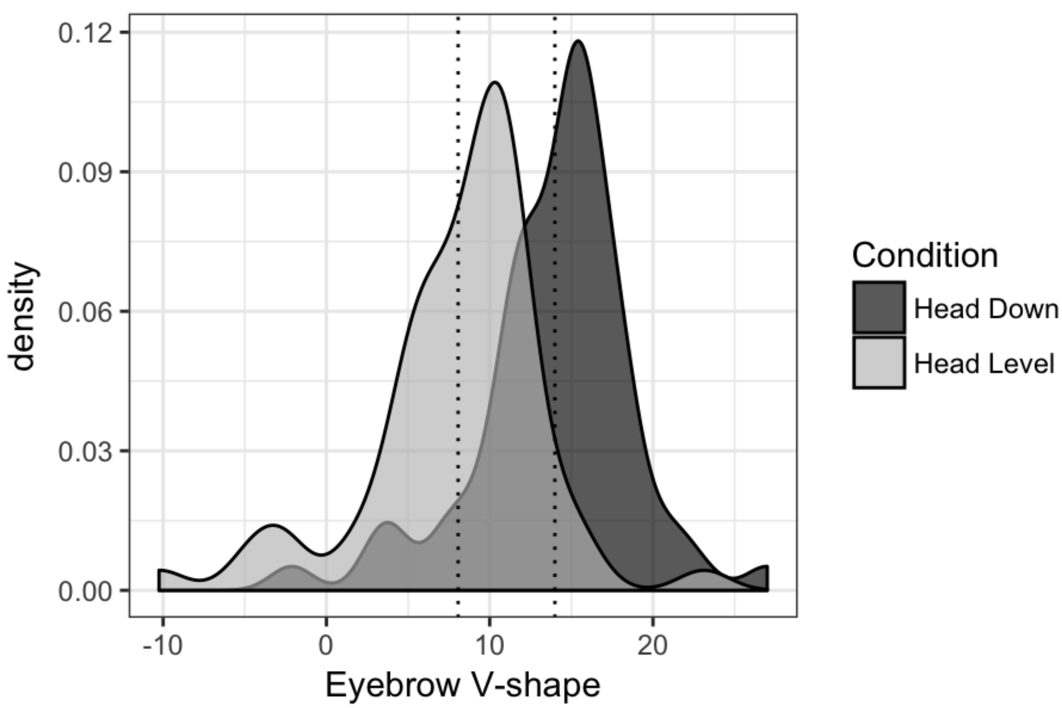


Figure 9. *Kernel density plot visualizing the distribution of eyebrow V-shape angle for all participants in each head-tilt condition, Study 5. Vertical dashed lines indicate the mean for each group.*

Next, a multilevel model predicting perceived dominance from head-tilt condition and random intercepts for judges indicated that the total effect of downward head tilt on perceptions of dominance was significant, b = .33, t = 7.38, p < .001, 95% CI: [.24 to .42]. This effect remained robust after controlling for target ethnicity and gender (see Table 1). In addition, a multilevel model predicting perceived dominance from head tilt condition and eyebrow V-shape, along with random intercepts for judges, indicated that V-shaped eyebrows led to increased perceptions of dominance controlling for the effect of head tilt, b = .03, t = 6.20, p < .001, 95% CI: [.02 to .04]. This effect was strengthened after controlling for target ethnicity and target gender (see Table 1).

The direct effect of head tilt on perceptions of dominance while controlling for eyebrow V-shape was significant but partially attenuated, b = .17, t = 3.26, p < .001, 95% CI: [.07 to .27]. Finally, the indirect effect of head tilt on perceptions of dominance via eyebrow V-shape was significant, b =.16, p < .01, 95% CI [.11 to .22].

Follow-up models outlining the a and b pathways while estimating additional random slopes and covariates, or using different analyses (e.g., repeated measures ANOVA), did not change the statistical significance or the direction of other pathways in the model (see Table 1 and SOM-U). In sum, the results of Study 5 indicate that tilting the head downward causes the eyebrow angle to take on an apparent V-shape, and V-shaped eyebrows are related to increased perceptions of dominance.

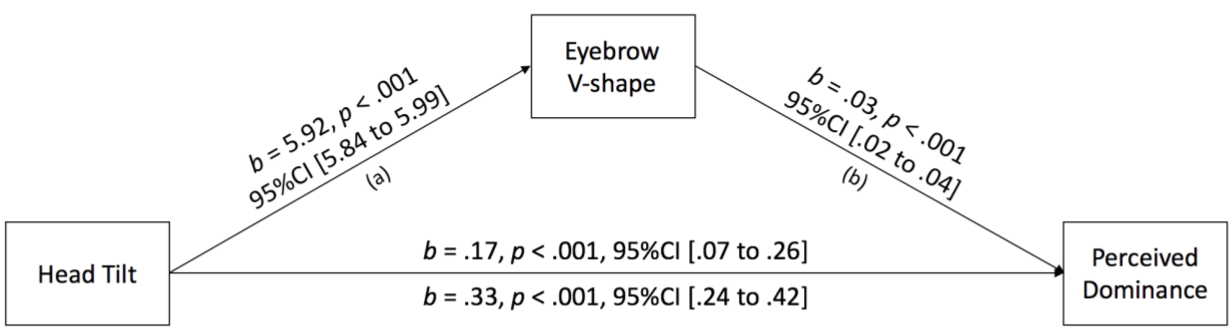


Figure 10. *Effect of manipulated head tilt on perceptions of dominance via changes to the apparent V-shape angle of the eyebrows*

Table 1. *Multi-level models indicating that head-tilt angle predicts perceptions of dominance via eyebrow angle, Study 5*

Variable added:	**"a" path [95%CI]**	**"b" path [95%CI]**	**"c" path [95%CI]**	**"c prime" path [95%CI]**
Baseline model	5.92 [5.84 to 5.99]	.03 [.02 to .04]	.33 [.24 to .41]	.17 [.07 to .27]
Model 2				
Baseline + Target Ethnicity	5.92 [5.84 to 5.99]	.04 [.03 to .05]	.33 [.21 to .44]	.12 [.02 to .23]
Model 3				
Model 2 + Target Gender	5.92 [5.84 to 5.99]	.03 [.02 to .05]	33 [.21 to .44]	.12 [.02 to .23]

Note. Numbers are unstandardized coefficients and, in brackets, 95% confidence intervals, for each path of the mediation model after including random slopes, and pertinent covariates. For additional modeling information, see results section of Study 5.

General Discussion

The current research provides the first evidence that tilting one's head downward causes the eyebrows to lower and take on a V-shape, creating the illusion of corrugator activity, or AU4, and this illusory movement in turn increases perceptions of dominance when eye gaze is directed forward. Across five studies, we found that tilting one's head downward functions as an action-unit imposter, generating the appearance of facial muscle activity that has a strong impact on social perceptions, where no such activity exists. This finding emerged from studies showing that: (a) the effect of downward head tilt on dominance perceptions cannot be attributed to alternative mechanisms such as a closed-and-contracted appearance, apparent mouth curvature, or increased vFWHr, (b) the upper face—where the eyebrows and eyes are localized—is necessary and sufficient for perceptions of dominance to emerge from a downward-head tilt, (c) tilting the head downward while holding eyebrow angle constant prevents the effect from emerging, and (d) tilting the head downward changes the appearance of the eyebrows by causing them to take on an apparent V-shape, and these visual changes are associated with increased dominance perceptions, even controlling for head tilt.

These findings also provide the first evidence that head movement alters the appearance of the face systematically, by creating the illusion of facial-muscle activity. Head movement is therefore likely to influence facial communication and emotion expressions, broadly speaking. While some might consider the head a source of noise that can obscure facial visibility, it should instead be considered a platform for communicating interpersonal information via the face without activating facial muscles. Supposedly "neutral" faces may be less inexpressive than they are often assumed to be.

Prior studies have shown that dynamic emotion expressions – which often include head movement – can enhance emotion communication (Cunningham, Wallraven, & Nusseck, 2009; de la Rosa et al., 2013). Future research should examine whether these findings might be partly attributable to the action-unit imposter effect; expressions that include corrugator activation (e.g., anger; Ekman & Friesen, 1978) might be perceived as more intense when paired with a downward-head tilt, due to the enhancement of appearance cues associated with AU4 (see Witkower, Tracy, & Lange, 2018). Similarly, facial coding (by humans or automated systems) might by unduly influenced by head tilt; the presence and/or intensity of AU4 could be misidentified in stimuli featuring a downwards tilted head. Future research should also assess whether these effects emerge as strongly when heads and faces are viewed live in 3D. One study found that individuals spontaneously tilt their heads down when asked to appear intimidating in a real-life 3D setting, likely due to the same mechanism (Hehman et al., 2013), but this remains an important issue for future work.

One limitation of this research is that we did not assess the full range of head-tilt angles, instead relying largely on 10-degree shifts. However, 10-degrees represents one of the smallest experimental manipulations of head-tilt angle that has been examined, making our approach quite conservative. Furthermore, these subtle shifts likely correspond to signaling in everyday life, thus increasing ecological validity.

In conclusion, this research provides the first evidence that tilting one's head downward increases perceptions of dominance by changing the appearance of the face without altering facial musculature. Social judgments of faces are thus based on perceptions formed from the face *and* movements of the head, making it critical that studies on face perception and facial expressions consider the head, the physical foundation of the face.

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