The Action Unit Imposter: Head position influences social perceptions by changing the appearance of the face

by

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The Action Unit Imposter: Head position influences social perceptions by changing the appearance of the face

submitted by	Zachary Witkower	in partial fulfillment of the requirements for
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Abstract

Facial structure and facial expressions play a crucial role in the communication of social information, but faces are rarely perceived in isolation. Instead, observers view faces as they rest upon their physical foundation: the head. Here, I argue that head position plays a critical role in face perception by causing the appearance of the eyebrows to change— paralleling the consequences of facial expressions— without using facial musculature. As a result, although tilting the head does not involve the activation of facial muscles, it may function as an imposter of facial muscle action by changing the appearance of the face. In the present dissertation, I test and support this broad account, and demonstrate its widespread generalizability, across 16 studies. First, in Chapter 2, I (a) provide evidence that a downwards head tilt increases perceptions of dominance, (b) demonstrate that this effect occurs by changing the apparent V-shape of the eyebrows, in particular, and (c) rule out the possibility that any of the other previously proposed mechanisms are viable explanations for observed effects. In Chapter 3, I test whether the AU imposter mechanism is likely to be a universal feature of human visual cognition, by assessing its impact on social perceptions among the Mayangna – members of an unindustrialized small-scale traditional society who have minimal exposure to North American culture. In Chapters 4 and 5 I demonstrate that the AU imposter mechanism systematically influences social perceptions of emotionally expressive faces, alongside neutral faces – including perceptions formed from expressions of anger (Chapter 4) and happiness (Chapter 5). Finally, in Chapter 6 I review the existing body of evidence in support of the AU imposter mechanism, outline theoretical and applied implications of the AU imposter, and provide avenues for future inquiry. Together, these six chapters outline how and why the head should be considered a platform for universally communicating salient interpersonal information via the face, and one

that can drastically alter, and in some cases categorically change, the message communicated from both neutral and expressive faces.

Lay summary

Here, I argue that head position plays a critical role in face perception by causing the appearance of the eyebrows to change—paralleling the consequences of tensing a specific facial muscle (i.e., the corrugator muscle)—but without the activation of any facial muscle activity. As a result, although head movement does not involve facial movement, it may function as an imposter of a facial expression, guiding social perceptions by changing the appearance of the face. In Chapters 1-3, I provide the first evidence in support of this action unit imposter account, and demonstrate that it is a universal feature of human perception. In Chapters 4 and 5, I demonstrate that the AU imposter mechanism influences perceptions of emotionally expressive faces, alongside neutral faces. Finally, in Chapter 6, I review existing support for the AU imposter mechanism, and outline the theoretical and applied implications of this work.

Preface

All of the work presented in this dissertation was conducted in the Emotion and Self lab (PI: Jessica Tracy), at the University of British Columbia, Vancouver campus. All projects and associated methods were approved by the University of British Columbia's Research Ethics Board [certificates #H07-02274].

A version of Chapter 2 has been published in the peer-reviewed journal *Psychological Science,* (Witkower & Tracy, 2019). This work was in collaboration with Jessica Tracy. ZW developed the study concept. Both authors contributed to the study designs. Testing and data collection were performed by ZW, who also analyzed and interpreted the data under the supervision of JT. ZW drafted the manuscript, and JT provided critical revisions. Kristin Laurin also provided helpful feedback on earlier drafts of this manuscript. ZW and JT approved the final manuscript for submission.

A version of Chapter 3 is currently under review (Witkower, Hill, Koster, & Tracy, under review). This work was in collaboration with Jessica Tracy, Alexander Hill, and Jeremy Koster. ZW and JLT developed the study concept. ZW, JLT, and AH, designed the studies, which were reviewed and critiqued by JK. Testing and data collection were performed by AH, with feedback from JK. ZW analyzed and interpreted the data, with feedback from JLT, AH, and JK. ZW and JLT drafted the manuscript, and all authors reviewed and provided additional feedback on the manuscript. All authors approved the final manuscript for submission.

A version of Chapter 4 has been published in the peer-reviewed journal *Emotion* (Witkower & Tracy, 2020). This work was in collaboration with Jessica Tracy. ZW developed the study concepts and study designs. Testing and data collection were performed by ZW, who also analyzed and interpreted the data under the supervision of JT. ZW drafted the manuscript, and JT provided critical revisions. ZW and JT approved the final manuscript for submission.

A version of Chapter 5 is currently being prepared for publication in a peer-reviewed journal (Witkower, Lange, & Tracy, 2020). This work was in collaboration with Jessica Tracy and Jens Lange. ZW developed the study concepts and study designs. Testing and data collection were performed by ZW and JL. Translating materials into German was done by JL. ZW analyzed and interpreted the data under the supervision of JT. ZW drafted the manuscript, and JT provided critical revisions. ZW, JT, and JL will approve the final manuscript for submission.

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Acknowledgements

The process of applying to graduate school is, in hindsight, quite bizarre. As a young and generally naïve college student, I moved to a new country and dedicated the next 6 years of my life to working with and learning from “Jessica Tracy” – a person who, for he most part, I had only seen on paper. Jess, I’m incredibly fortunate to have stumbled in your direction, and glad that you decided to take a chance on me despite my very very unimpressive GRE scores. You’ve provided me with tremendous support, guidance, resources, and opportunities. You’re tough on me and you challenge me, but don’t give me anything that you know I can’t handle. I’ve been changing “we” to “I” in my dissertation, because that’s how dissertations are supposed to be formatted, but it feels remarkably disingenuous because *none* of the research presented here (in fact, almost none of my research, ever) has happened without you by my side. Although this will change in the future, I’m excited to bring all of your lessons with me. I have much more to say, and I’m excited to tell you in a letter I’m currently drafting, but this isn’t the time or place. I have until tomorrow at 3PM to write the rest of my acknowledgements, finalize my lay summary and abstract, and ~~start~~ finish the reference section. Jess, thank you. If one day I find myself in a tenure-track job at an R1 with my own team of graduate students, I hope to be the type of mentor for them that you have been for me.

I want to give a special thanks to my dissertation committee – Jess Tracy, Kristin Laurin, and Alan Kingstone – for taking the time to read so much about head tilts, and asking me questions that hopefully don’t cause me to flounder during my defense.

I want to thank all of my collaborators – including co-authors and informal collaborators – who I've conducted research with over the years. And, of course, a special thanks to the colleagues who have made these particular 16 studies possible:

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7) Steve Heine
8) Alec Beall
9) All of my friends who were the "targets" in Study 12.

I also want to thank Chris Barlett, who gave me the opportunity to pursue this bizarre topic when I was only a sophomore at Gettysburg College 8 years ago. The first time I told him about some of my head tilt ideas, he looked at me like I was a crazy person. To this day, I'm not sure if he *really* believed in the things I was saying at the time. But that never mattered – he invested in *me,* not just my idea, and gave me the resources to make my ideas come to life. For that, I'm forever grateful. My CV might not show it, but Chris is one of the biggest reasons that any of this research happened in the first place. To this day we're still sitting on head tilt papers that never got published.

I also want to thank my sister for her unwavering support, and calling me out when I'm wrong. Nobody keeps me honest the way she does. She always has been, and always will be, my best friend, even though she's a loser. I also want to thank my other best friend, and girlfriend, Hannah. Hannah, you're a terrible gold digger, but an amazingly supportive girlfriend. Thank you for becoming a psychology expert for me, and for taking on all of life's adventures. Finally, thank you Luna. I love wrestling with you, even though Hannah gets mad when we do it on the same couch as her. I'm excited to continue buying your friendship with leftover bacon and dog treats.

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Dedication

After my dad passed away, the world moved on. A stranger took his office, his credit cards expired, his cellphone number was eventually disconnected, and all that remained were memories and photographs. I quickly learned that almost everything has an expiration date. Although this was a tough pill for me to swallow, it was an important lesson, and one that I'm fortunate to have learned at such a young age.

I'm passionate about the process of turning thoughts and ideas into facts and knowledge, but I also value the permanency of important discoveries; "things" and "people" don't last forever, but facts and discoveries have the potential to. Charles Darwin and William James didn't get everything right, but in some cases, they were pretty close. Their thoughts and ideas transformed into discoveries and contributions that didn't just expire like a credit card. Instead, they created a foundation of knowledge that Zak Witkower – a complete stranger who they've never met, but has a similar passion for uncovering facts and answering questions – keeps alive and builds on 150 years later.

I hope to develop a foundation of knowledge that, one day, a complete stranger who I've never met, but has a similar passion for uncovering facts and answering questions, can keep alive and build on. Sometimes science progresses one funeral at a time, but if you contribute important, interesting, persuasive, and innovative research, you can create something that is everlasting. That's the imperishability that I have learned to value, and will always chase.

My dissertation is dedicated to my father and my mother.

My father instilled and fostered my sense of curiosity with his inquisitive eagerness. I deeply admired this about him, even when it was embarrassing, like when he asked the 17-year-old cashier at a skateboard shop to explain the physics of an ollie. He provided me with a template for how to be a fun, charismatic, curious, loving, ambitious, resilient, and family-oriented person. The image he left behind provides me with a framework to live up to long after his passing.

My mother uses her actions, words, and personal triumphs to teach me that *nothing* should *ever* get in my way. She motivates me to follow my passion, while emphasizing the importance of maintaining stick-to-itiveness if I want to find success. Most importantly, she's taught me to stay positive throughout life's ups and downs.

Without them, I quite literally wouldn't be here. With them, I hope to discover something imperishable.

Head movement in social communication

Facial structure and facial expressions play a crucial role in the communication of social information (Oosterhof & Todorov, 2008; Ekman, 2006; Hareli, Shomrat, & Hess, 2009; Tskhay & Rule, 2013; Hess, Adams, & Kleck, 2005; Said, Sebe, & Todorov, 2009). However, faces are rarely perceived in isolation. Instead, observers view faces as they rest upon their physical foundation: the head. Despite this basic fact of human anatomy, research on facial expressions and morphology continues to blossom, while research on the role of head position in social perceptions remains largely unexplored. Here, I propose a novel account of social perception from the face. Specifically, I argue that head position plays a critical role in face perception by causing the appearance of the eyebrows to change— paralleling the consequences of facial expressions— without using facial musculature. As a result, the head should be considered a platform for communicating salient interpersonal information via the face, and one that can drastically alter, and in some cases categorically change, the message communicated from both neutral and expressive faces. Research on facial perception and impression formation should therefore consider the face in the context of its physical foundation: the head.

Prior research on head movement and social communication: Contradictory effects

Head position can be characterized by three core movements: head pitch, head yaw, and head roll (see Figure 1). Head pitch (AU 53 and 54 in the Facial Action Coding System or FACS; Ekman & Friesen, 1978) involves tilting the head up or down – for example, the movement employed during a “yes” gesture. Head yaw (AU 51 and 52 in FACS) involves turning the head to the side (e.g., left or right) – for example, the movement employed during a “no” gesture. The final movement, head roll (AU 55 and 56 in FACS) involves rocking the head from side to side – for example, the behavior you would employ to raise an ear to the sky.

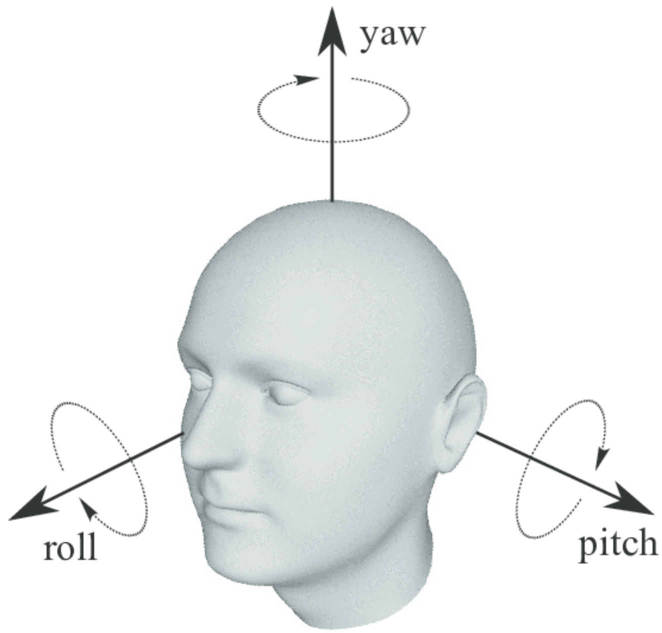


Figure 1. Illustration of three core head movements: head pitch, head yaw, and head roll. Figure reproduced from Fernandez, Usamentiaga, Carus, and Casado, (2016).

Although all three of these head movements might contribute to social perceptions, I focus on downwards head tilt in the current dissertation, for several reasons. First, there is strong evidence that nonverbal displayers spontaneously employ a *downwards* head tilt for the purpose of social signaling (Hehman, Leiutner, & Gaertner, 2013; Witkower & Tracy, 2020; Livingstone & Palmer, 2016; Keltner, 1995), whereas very little evidence suggests that individuals spontaneously demonstrate head roll or yaw for social signaling (with the exception of culturally-constructed emblematic gestures like the “no” gesture; e.g., Livingstone & Palmer, 2016). Second, studies suggest that a downwards head tilt has a large effect on perceptions of dominance, whereas head yaw and roll have a much smaller effect on any social perceptions, across the literature (e.g., Bee, Franke, & Andre, 2009; Hess, Adams, & Kleck, 2007).

Third, and related to the previous point, studies exploring the impact of head tilt on social perceptions of dominance have reported contradictory results, raising a clear need for additional research on this issue. In particular, some researchers have suggested, and found, that a downwards head tilt increases perceptions of dominance (e.g., Hehman et al., 2013; Torrance, Holzleitner, Lee, DeBruine, & Jones, 2020; Zhang, Lin, & Perrett, 2020; Toscano et al., 2018), a form of social rank characterized by the use of intimidation or threat to influence others, whereas other suggested and found that a downwards head tilt decreases perceptions of dominance (Mignault & Chaudhuri, 2003; Lyons et al., 2000; Rule, Adams Jr, Ambady, & Freeman, 2012; Marshall, Barrolacci, & Burke, 2020). Based on this literature, it seems clear that head tilt is an important head movement for social communication, but no clear conclusion can be drawn about the specific direction of its effect on perceptions of dominance.

One possible explanation for the conflicting findings that have emerged is that researchers have not controlled for eye gaze in a consistent manner. For example, in some studies researchers asked displayers to pose expressions with their eye gaze averted in the same direction that their head was tilted (e.g., Mignault & Chaudhuri, 2003; Rule et al., 2003; Marshall, Barrolacci, & Burke, 2020; Toscano, Schubert, & Giessner, 2018); whereas in others, displayers are asked to pose with eye contact maintained toward an observer across head tilt positions (e.g., Hehman et al., 2013; Torrance et al., 2020; Zhang et al., 2020; Toscano et al., 2018). Eye gaze direction is a meaningful behavior that provides information about others' intentions (Calder et al., 2002), mental states (Fernandez-Duque & Baird, 2005), and future behaviors (Nummenmaa, Hyönä, & Hietanen, 2009), and can mobilize observers to engage in social behaviors (Khalid, Deska, & Hugenberg, 2016; Adams & Kleck, 2005; Adams, Pauker, & Weisbuch, 2010; Hess, Adams, & Kleck, 2007). Given that eye gaze is important for social perception and human interaction, studies examining the role of head position on social perceptions must systematically control for the impact of eye gaze direction. In fact, studies that have used stimuli in which the head is tilted down and eye contact is maintained yield an increase in perceptions of dominance (Hehman et al., 2013; Torrance et al., 2020; Zhang et al., 2020; Toscano et al., 2018; Witkower & Tracy, 2019), whereas studies using stimuli in which the head is tilted down and eye gaze is averted towards the ground yield a decrease (or no change) in perceptions of dominance (Keltner, 1995; Shariff & Tracy, 2009; Tracy & Robins, 2008; Tracy, Robins, & Schriber, 2009; Witkower & Tracy, 2019; Witkower, Mercadante, & Tracy, 2020; Mignault & Chaudhuri, 2003; Rule et al., 2003; Marshall, Barrolacci, & Burke, 2020; Toscano et al., 2018). It is therefore critical that research in this domain does not confound eye gaze with head tilt.

Prior research on head movement and social communication: Inconsistent mechanisms

Not only have prior studies produced conflicting effects regarding the impact of head tilt on social perceptions of dominance, but researchers have also proposed somewhat conflicting of explanations for these effects. Some theories suggest that head movements influence social perceptions by changing the appearance of the face, and pinpoint particular regions of the face as critical for shaping these perceptions. Others, in contrast, suggest that head movement influence perceptions by changing the position of the head relative to the body. Below, I review all of these previously proposed accounts.

One account suggests that a downwards head tilt functions as a *closed and contracted* nonverbal behavior (Mignault & Chaudhuri, 2003; Rule, Adams Jr, Ambady, & Freeman, 2012).

Closed and contracted bodily displays cause individuals to appear physically smaller (Marsh et al., 2009), and given that smaller individuals are perceived as lower in rank (Blaker & Van Vugt, 2014) —likely as a result of a more ancient association between sheer size and coercive power (Blaker & van Vugt, 2014; Stulp, Buunk, Verhulst, & Pollet, 2015) – closed and contracted nonvebral behaviors decrease perceptions of dominance (e.g., Marsh, Henry, Schechter, & Blair, 2009; Anderson & Kilduff, 2009; Marsh, Yu, Schechter, & Blair, 2009; Tiedens & Fragale, 2003). In sum, a downwards head tilt could function as a *closed and contracted* nonverbal behavior (Mignault & Chaudhuri, 2003; Rule, Adams Jr, Ambady, & Freeman, 2012), which will decrease perceptions of dominance by making a nonverbal displayer appear physically smaller.

A second account suggests that tilting the head down might signal one's preparedness for an agonistic encounter *by protecting the neck* – specifically, the carotid artery, jugular vein, and trachea – vulnerable anatomical features that are critical for survival. Although no studies have provided empirical support for this mechanism in humans, Hehman et al. (2013) noted that a downwards head tilt is frequently adopted during fights by modern-day boxers and mixed martial arts fighters.

A third account suggests builds on research on impression management and self-representation (Makhanova, McNulty, & Maner, 2017; Marshall, Bartolacci, & Burke, 2020; Burke & Sulikowski, 2010). By tilting one's head down, a nonverbal displayer brings their eyes physically closer to an observer, while simultaneously moving their chin and jaw further away. Facial features (in fact, any object) further away from an observer are, in turn, perceieved as visibly smaller in an observer's visual field. Larger eyes and smaller jaws are, in turn, perceived as less dominant (e.g., Windhager, Schaefer, & Fink, 2011; Keating, 1985; Keating, Mazur, &

Segall, 1981; Oosterhof & Todorov, 2008). Tilting the head down could therefore decrease perceptions of dominance by causing the eyes to appear larger while decreasing the apparent size of the jaw (Makhanova, McNulty, & Maner, 2017).

A fourth account builds on research on the Noh mask (Lyons et al., 2000). The *Noh mask* is a full-face mask portraying a facial expression of happiness (i.e., a smile), worn by skilled actors in the Noh tradition in Japan, which, as shown by Lyons et al. (2000), can lead to a variety of perceptions based on the viewpoint of the observer. In particular, Lyons et al. (2000) demonsrated that when the mask is tilted down the curvature of the lips appears to take on a more intense smile. Given that highly intense smiles lead to perceptions of happiness – an emotion that communicates warmth and affiliation and should therefore decrease perceptions of dominance (e.g., Kraus & Chen, 2013) – a downwards head tilt, which has the same perceptual effects as tilting the Noh mask down, might decrease perceptions of dominance formed from smiling faces by changing the apparent curvature of the lips. In the one study testing this possibilty with neutral and unexpressive (human) faces (Mignault & Chaundhuri, 2003), downward tilted heads were perceived as having mouths that are more similar in appearance to a smile. However, targets with their head tilted down while maintaining a neutral facial expression were judged as more *sad* and *inferior* – constructs contradictory with happiness and smiling (and inconsistent with dominance) – despite the fact that observers identified the corners of the mouth as more consistent with the appearance of a smile. Given this pattern of results, it seems unlikely that the downwards head tilt influenced perceptions as a result of its effect on the apparent curvature of the mouth, but I consider it here as a possible mechanism due to its theoretical plausibility.

A final account that has been proposed – in fact, the most prominent and well-supported theory on this topic, put forward by Hehman, Leitner, and Gaertner (2013) – suggests that a downwards head tilt increases perceptions of dominance by changing the visible Facial width-to-height ratio (vFWHr). The WHR is a holistic facial measurement characterized by the bizygomatic width of the face (i.e., the distance between the left and right Zygion, or cheekbones) divided by the height of the face (i.e., the distance between the mid-brow to upper lip). By tilting the head downward, a nonverbal displayer decreases the apparent height of their face, while keeping the width of their face the same, thus increasing their apparent visible facial width-to-height ratio (see Figure 2).

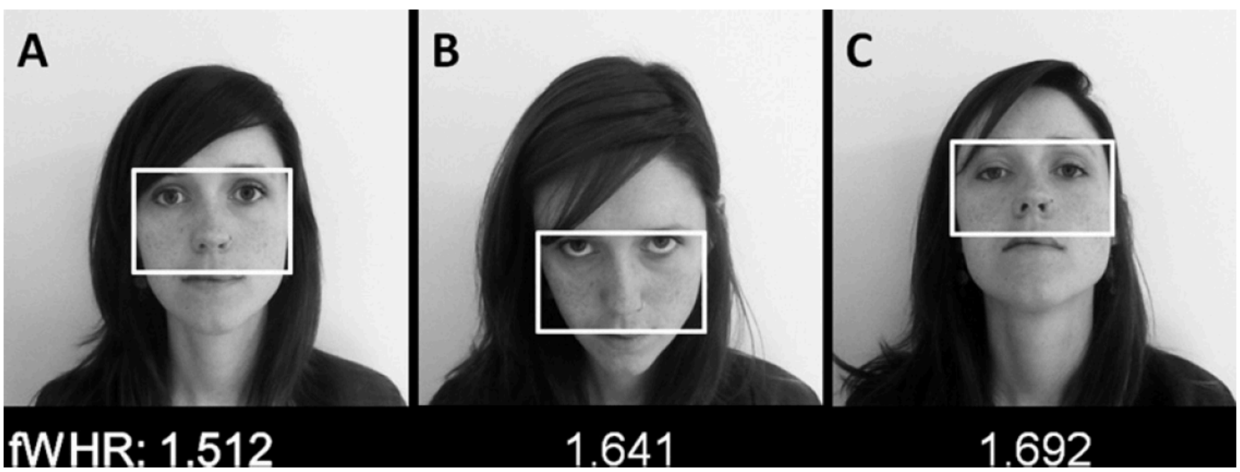


Figure 2. Graphical representation of how tilting the head down increases the visible facial width-to-height ratio. Note: Figure reproduced from Hehman et al., 2013 (p. 747).

Facial width to height ratio is, in turn, associated with increased perceptions of dominance (Geniole, Denson, Dixson, Carré, & McCormick, 2015; but see Kosinski, 2017), and therefore, tilting the head down is thought to increase perceptions of dominance by increasing this ratio. This visual mechanism is not specific to only a downwards head tilt; tilting the head either upward or downward increases the vFWHr, so both movements should increase perceptions of dominance according to this account. Testing this account, Hehman et al (2013) measured the vFWHr of neutral- and downward-tilted heads and found that (a) tilting the head down (or up) does increase the vFWHr, (b) participants spontaneously tilt their heads down (or up) when trying to appear intimidating, and (c) downward tilted heads, with resulting increased vFWHr, are perceived as more intimidating.

Overview of past research

In sum, the existing literature examining the role of head tilt in social perception outlines five distinct mechanisms that might explain these effects. These include the (1) open-and-expansive account, (2) protecting the neck account, (3) size of the chin and eyes account, (4) the Noh Mask account, and (5) the visible facial width-to-height ratio (vFWHr) account. Of these five mechanisms, three of them suggest that a downwards head tilt should decrease perceptions of dominance (closed and contracted, size of the chin/eyes, Noh mask), whereas two suggest that a downwards head tilt should increase perceptions of dominance (protecting the neck, vFWHr). Taken together, the previous research literature has therefore suggested that a downwards head tilt can both increase and decrease perceptions of dominance, and proposed inconsistent and in some cases directly contradictory visual mechanisms to explain these effects. As a result, head tilt is likely to have some influence on social perceptions, but few clear conclusions can be drawn about the specific direction of this effect, or the mechanism underlying it.

The Action Unit Imposter mechanism

The present work challenges all of these prior accounts and proposes a novel account of social perception from the face and head. Specifically, I argue that head position in the form of downward-pitch rotation, or tilt, causes the eyebrows to take on an apparent V-shape and become lowered. These appearance cues, in turn, guide perceptions of dominance. Critically, these cues are identical to those associated with Action-Unit (AU) 4 (i.e., corrugator activation; Ekman & Friesen, 1978). Expressions with activation of AU4 are perceived as dominant, angry, and threatening (Keating & Bai, 1986; Hareli, Shomrat, & Hess, 2009). Therefore, I argue that head position may coopt the psychology of facial expression perception by creating the *visual illusion* of facial dynamics; 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 to occur to the face, resulting in the same social-perceptual consequences of that face. In short, the AU imposter mechanism is therefore hypothesized to increase perceptions of dominance by changing the appearance of the face – specifically, the V-shape of the eyebrows.

Prior research has not examined whether tilting the head downward causes the appearance of eyebrows to change, but studies have shown that 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). These prior results are based on *actual* facial muscle activation by a nonverbal displayer (i.e., facial expressions), or unnatural manipulations to facial morphology across *different* displayers (i.e., the dimensions and shapes of the faces and heads). I believe that these same changes in facial appearance *naturally* occur to a nonverbal displayer when the head is tilted down and the face remains immobile (assuming similar viewing conditions; Kappas, Hess, Barr, & Kleck, 1994), and that shifts in head movement therefore indirectly influence social perceptions via facial appearance changes. Head tilt therefore functions as an action-unit imposter: causing the same effect as a facial-muscle movement, despite the fact that no facial muscle movement occurs.

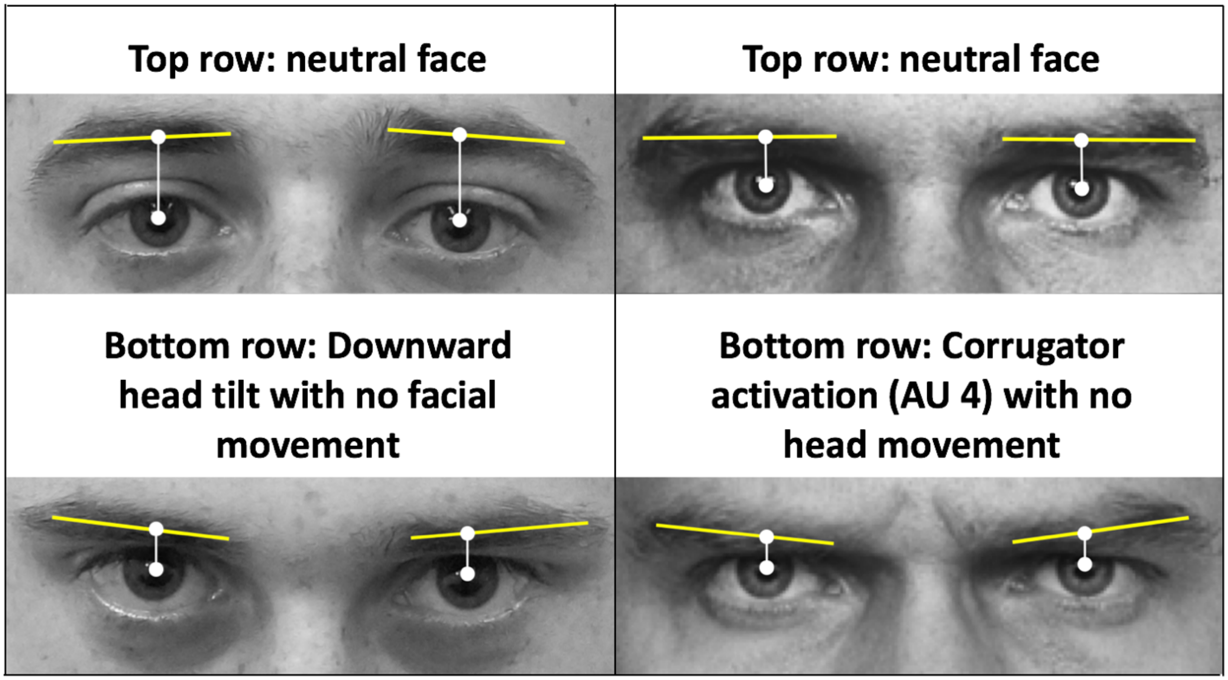


Figure 3. Visualization of the mechanism proposed by the novel action-unit imposter account. Top: neutral head and face. Bottom: downward-head tilt (left), and activation of AU4 (right). Both movements create the appearance of a V-shape and lowering of the eyebrows.[1]

Dissertation Roadmap

In this dissertation, I provide the first evidence for the existence and perceptual consequences of the Action Unit Imposter mechanism in social judgments. First, in Chapter 2, I (a) provide evidence that a downwards head tilt increases perceptions of dominance, (b) demonstrate that this effect occurs by changing the apparent V-shape of the eyebrows, in particular, and (c) rule out the possibility that any of the other previously proposed mechanisms, outlined above, are viable explanations. In Chapter 3, I test whether the AU imposter mechanism is likely to be a universal feature of human visual cognition by assessing its impact on social perceptions among the Mayangna – members of an unindustrialized small-scale traditional society, who have minimal exposure to North American culture and are unlikely to have learned about the AU imposter from cross-cultural transmission. In Chapters 4 and 5 I demonstrate that the AU imposter mechanism systematically influences social perceptions of emotionally expressive faces, alongside neutral faces – including perceptions formed from expressions of anger (Chapter 4), and happiness (Chapter 5). Finally, in Chapter 6 I review the existing body of evidence in support of the AU imposter mechanism, outline theoretical and applied implications of the AU imposter, and provide avenues for future inquiry.

Testing the Action Unit Imposter hypothesis

The following 8 studies, which are published in Witkower and Tracy (2019), provide the first test of the action unit imposter account. Specifically, I test whether (a) a downwards head tilt increases or decreases perceptions of dominance, (b) the action unit imposter mechanism can account for the effect of head tilt on perceptions of dominance, and (c) whether any other previously proposed mechanisms can also account for the effect of a downwards head tilt on perceptions of dominance.

Study 1

Our AU-imposter account, consistent with the vFWHr hypothesis and the neck covering hypothesis, but contrary to the closed-and-contracted, Noh Mask, size of chin/eyes hypotheses, suggests that downwards-head tilt should *increase* perceptions of dominance from a neutral (i.e., completely inactive) face. Therefore, the purpose of Study 1 was to test whether a downwards head tilt *increases* or *decreases* perceptions of dominance formed from a neutral face when eye contact is maintained with an observer.

Method and materials

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 (see below), resulting in a final sample of 101 participants (41% female; age range = 19- 62, Median = 30 years). A power analysis indicated that my 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 = .50, no sphericity correction). However, given my goal of seeking to uncover a robust effect to help resolve the conflicting predictions offered by extant theoretical accounts, I elected to roughly double that N. Participants viewed three human-like male avatars in a randomized order and judged the dominance of each.

Attention Check Question

Prior to being debriefed, all participants responded to an attention check question developed in past research (e.g., Oppenheimer, Mayvis, & Davidenko, 2009; Witkower et al., 2019). Specifically, participants were provided the following paragraph of text:

"Research in decision making shows that people, when making decisions and answering questions, prefer not to pay attention and minimize their effort as much as possible. Some studies show that over 50% of people don't carefully read questions. If you are reading this question and have read all the other questions, please select the box marked 'other' and type 'Decision Making' in the box below. Do not select "predictions of your own behavior." Thank you for participating and taking the time to read through the questions carefully!"

Participants were asked to select one of the four possible answer choices: (1) "Predictions of your own behavior", (2) "Predictions of your friends' behavior", (3) "Political preferences", or (4) "Other (Please specify) ________". Any respondents who did not select option 4 ("Other") and indicate "Decision Making" (not case sensitive) in the text field were excluded from final analyses.

Stimuli.

Avatars were generated with Poser Pro (2014; see Figure 4, 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; Witkower & Tracy, 2019).

Figure 4. *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; also see Witkower, Hill, Koster, & Tracy, 2021) 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." For additional validation of these four items, see Witkower, Hill, Pun, Baron, Koster, & Tracy, 2021). Participants rated their agreement with each statement, for each target, on a scale ranging from 1 (*not at all*) to 7 (*very much*).

Exploratory measures

As additional exploratory measures, participants evaluated the perceived agency and communion of each target. Agency, defined as one's striving to gain social rank, and communion, defined as one's striving to relate to and cooperate with others (Bakan, 1966; Diehl, Owen, & Youngblade, 2004), are both closely related to dominance; dominant individuals strive for social rank, but via intimidation and not cooperation. Therefore, perceived dominance is characterized by perceptions of perceived high agency and perceived low communion (Witkower et al., 2019). Perceived agency was assessed by having participants indicate the extent to which the person in each image is "Self-Assured", "Assertive", and "Self-Confident" ($\bar{\alpha}$ = .83; Wiggins, Trapnell, & Phillips, 1988; Wiggins, 1979). Perceived communion was assessed by having participants indicate the extent to which the person in each image is "Tender", "Accommodating", "Gentlehearted", and "Kind" ($\bar{\alpha}$ = .93; Wiggins, Trapnell, & Phillips, 1988).

I expect a downwards head tilt to lead to the highest perceptions of agency, and the lowest perceptions of communion, when compared to all other head angles.

As a final exploratory measure, participants evaluated the prestige of each target using an abbreviated version of the Prestige scale ($\overline{\alpha}$ = .85; Cheng, Tracy, & Henrich, 2010). Prestige is a form of high rank that is distinct from dominance, and defined as the demonstration of knowledge and expertise for respect, admiration, and freely-conferred followership. The four items constituting the abbreviated prestige scale (chosen because they had the highest factor loadings on a prestige factor in initial studies validating the overall scale; see Cheng et al., 2010; also see Witkower, Hill, Koster, & Tracy, 2021) were: "This person would be considered and expert on some matters", "This person's unique talents and abilities would be recognized by others", "People would seek this person's advice on a variety of matters", and "Members of this person's group respect and admire him." For additional validation of these four items, see Witkower, Hill, Pun, Baron, Koster, & Tracy, 2021). Given that I expect a downwards head tilt to communicate dominance in particular, rather than alternative prosocial forms of social rank, I expect a downwards head tilt to increase perceptions of dominance but not prestige.

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 and neck protection hypothesis, predicts that downward head tilt – a contracted behavior that protects the neck – should *decrease* perceived dominance, whereas upward tilt – an expansive behavior that exposes the neck – should increase it. Similarly, the Noh Mask 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 5; *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 ($p < .001$, $d = .37$).

Exploratory analyses

Although the effect reported above – the effect of head tilt head tilt on perceptions of dominance – was the primary test of my hypotheses, as exploratory analyses I examined how head tilt influenced perceptions of agency, communion, and prestige, and whether the primary hypothesized effect of head tilt on perceptions of dominance varied by the gender of the participant.

A one-way repeated measures ANOVA uncovered a significant effect of head tilt on perceptions of agency, $F(2,200) = 13.59$, $p < .001$, $\eta_p^2 = .11$, indicating that a downward head tilt was judged to be significantly more agentic than a neutral and an upwards tilt (*p*s < .004, *d*s= .51 and .21, respectively). In addition, an upwards head tilt was judged to be significantly more agentic than a neutral head angle, but the magnitude of this effect was nearly half the size of that of downward tilt vs. neutral (p = .002, d = .30).

A one-way repeated measures ANOVA uncovered a significant effect of head tilt on perceptions of communion, $F(2,200)$ =27.96, $p < .001$, $\eta_p^2 = .20$, indicating that a downward head tilt was judged to be significantly lower in communion than a neutral and an upwards tilt (ps < .001, ds= .74 and .40, respectively). In addition, an upwards head tilt was judged to be significantly lower in communion than a neutral head angle, but the magnitude of this effect was half the size of that of downward tilt vs. neutral (p = .002, d = .34).

A one-way repeated measures ANOVA uncovered a significant effect of head tilt on perceptions of prestige, $F(2,200) = 9.00$, $p < .001$, $\eta_p^2 = .07$, indicating that a downward head tilt was judged to be significantly lower in prestige than a neutral and an upwards tilt (ps ≤ .016, ds= .35 and .24, respectively). An upwards head tilt was not judged to be significantly different in prestige than a neutral head angle (p = .07, d = .18).

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. A main effect of condition emerged, $F(2,297) = 20.77$, $p < .001$, $\eta_p^2 = .12$, indicating that a downward head tilt was judged to be significantly more dominant than a neutral and an upwards tilt (ps < .001). A main effect of gender also emerged, $F(1,297) = 9.22$, $p = .003$, $\eta_p^2 = .03$, indicating that female participants rated the target as more dominant than male participants. No significant interaction emerged, $F(2,198) = .13$, $p = .88$, $\eta_p^2 = .001$, suggesting that the extent to which head tilt influenced perceptions of dominance did not vary by the participant's sex.

Discussion

Consistent with the AU-imposter, vFWHr, and neck protection hypotheses, but inconsistent with the closed-and-contracted and Noh Mask 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. Finally, consistent with dominance being a highly agentic but antisocial strategy for rank attainment, a downwards head tilt was also identified as higher in agency but lower in communion than a neutral and upwards head tilt.

Study 2

Method

Study 2 was a preregistered attempt to replicate the primary 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/342zs).

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 eye gaze directed toward the viewer (see Figure 4, 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 my 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 5). 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. 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.

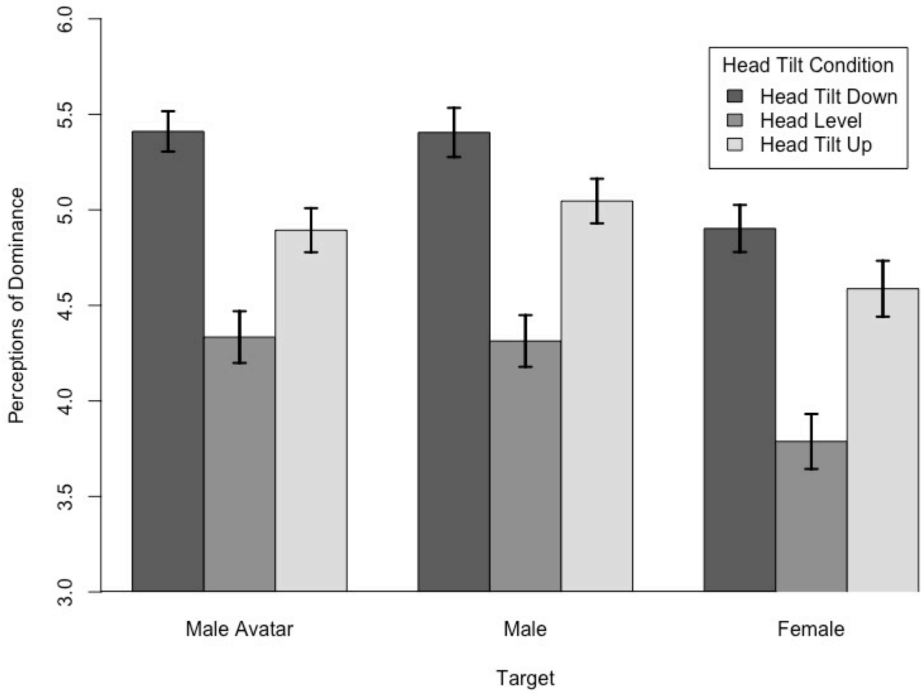


Figure 5. Mean perceptions of dominance by head tilt and target gender, Study 1 (bars on left) and Study 2 (bars in the middle and on right). *Note.* Error bars indicate +/- 1SE from the mean.

Study 3

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; Marshall, Barrolacci, & Burke, 2020; Toscano, Schubert, & Giessner, 2018). 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 et al., 2013; Torrance et al., 2020; Zhang et al., 2020; Toscano et al., 2018). I 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/342zs).

Method and materials

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). This exceeded the 22 participants necessary for 90% power to detect a significant interaction, based on the average correlation among repeated measures from Study 1 (r = .35) and an estimated effect size of η_p^2 =.08 (the smallest effect size uncovered in Study 1).

Stimuli and procedure

Stimuli were similar to those used in Study 1, with two exceptions. First, I 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 6), 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 my 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).

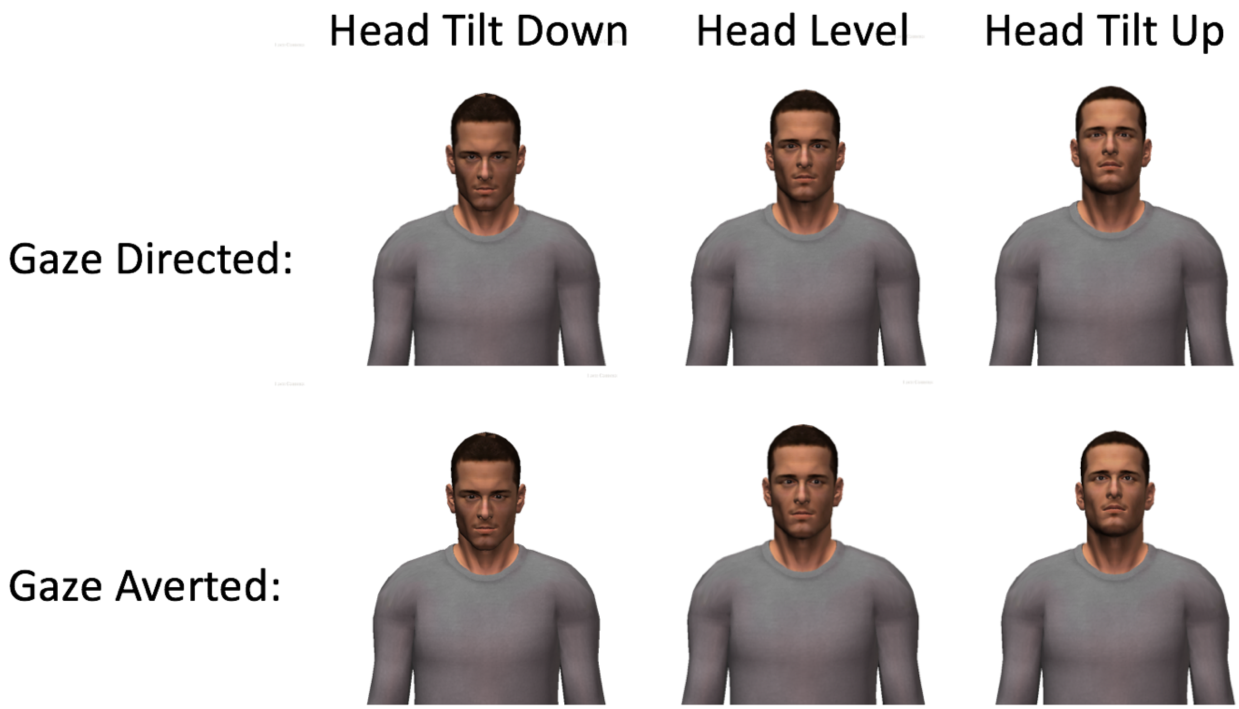


Figure 6. *Stimuli used in Study 3.*

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 7).

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 7; *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, $F(2,98)=.68$, $p=.49$, $\eta_p^2=.01$, $ps \geq .55$, $ds \leq .19$. 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. More broadly, this could suggest that any effects of eye gaze being averted could overwhelm the signal communicated from a downwards head tilt such that the effect of head tilt is no longer salient when eye gaze is averted.

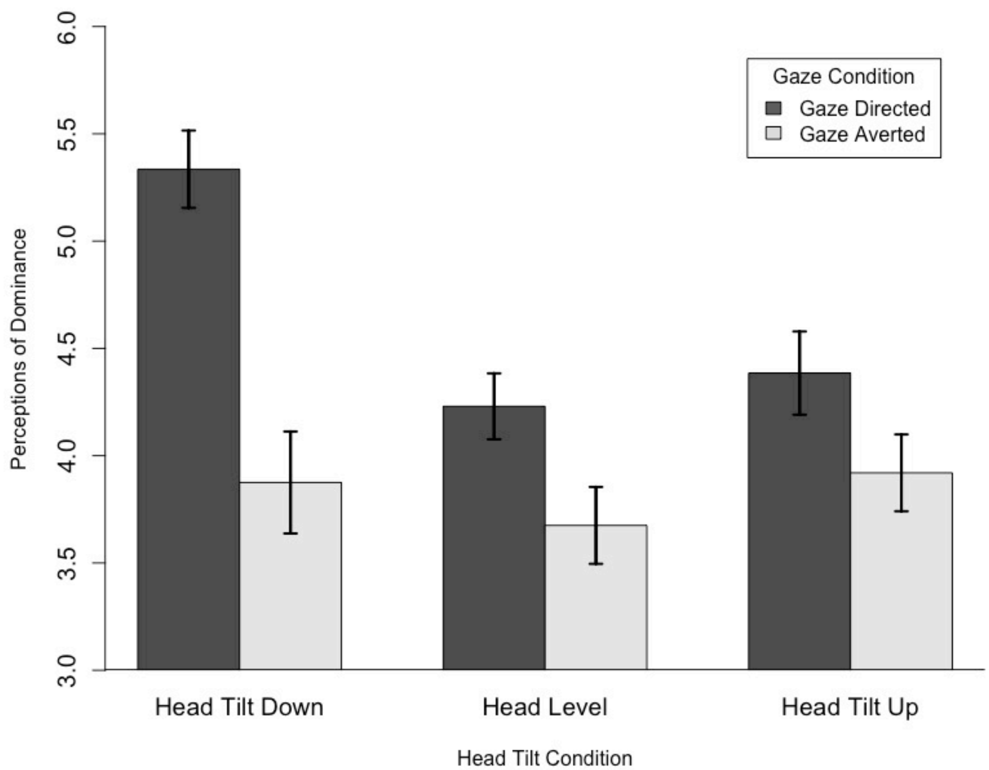


Figure 7. *Mean perceptions of dominance by condition, Study 3.*
Note. Error bars illustrate +/-1SE from the mean.

Study 4

In Study 4 I sought to stringently test the visible FWHr hypothesis by manipulating vFWHr independently of head-tilt direction. I preregistered my hypothesis that a downward-head tilt would increase dominance perceptions even when controlling for changes in vFWHr (osf.io/342zs). Stated differently, if the head is tilted down but vFWHr is not increased, I predicted that downwards-head tilt would still increase perceptions of dominance—in contrast to predictions that emerge from the vFWHr hypothesis.

Method and materials

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 my pre-registration, resulting in a final sample of 602 participants (52.3% female; age range=18-72, 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. This was roughly consistent with my pre-registered sample of 570 participants, which is necessary to uncover an effect size of $f = .15$ in a between-subject ANOVA, based on an alpha of .016 (anticipating a Bonferroni correction for 3 groups) and 80% power. 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. I 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

I developed stimuli in which vFWHr was systematically manipulated independently of head-tilt angle. I 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), 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 8).

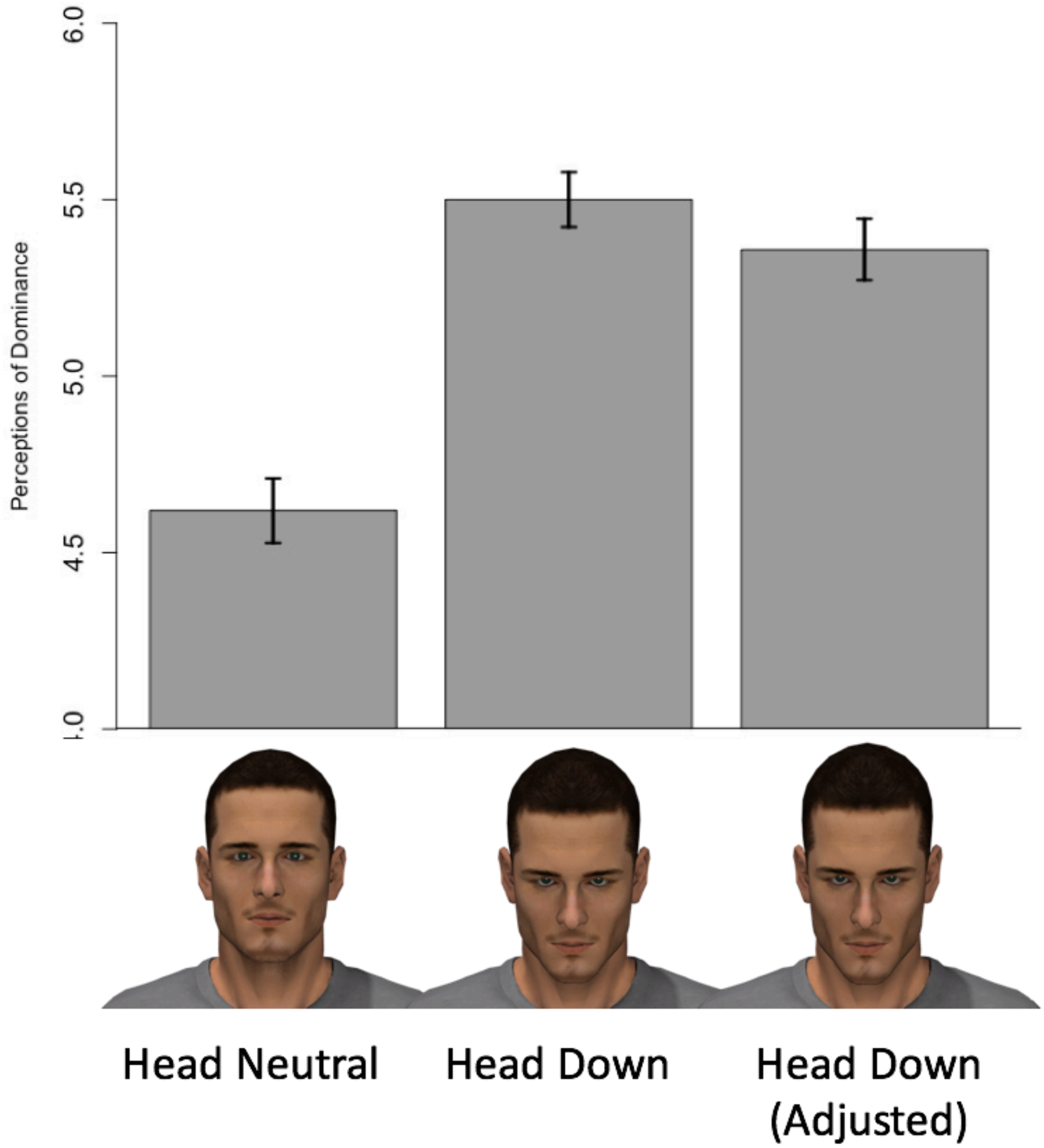


Figure 8. *Stimuli and results from Study 4*.
Note. Error bars indicate ±1SE from the mean.

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 8). 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.

Study 5

Our results thus far support my AU-imposter hypothesis and not any alternative hypotheses; my next studies pitted the AU imposter against all previously proposed mechanisms, while also providing stringent tests of the AU-imposter account. This AU imposter leads to several narrower predictions not shared with any other accounts. 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. In contrast, if changes to the appearance of *any* other parts of the face – including the neck, jaw, mouth, head, body, or facial width-to-height ratio – explain the effect of a downwards head tilt on perceptions of dominance, a downwards head tilt should *not* increase perceptions of dominance when participants are only shown the eyebrows and eyes. I 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.

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. In contrast, if changes to the appearance of *any* other parts of the face – including the neck, jaw, mouth, head, body, or facial width-to-height ratio – explain the effect of a downwards head tilt on perceptions of dominance, a downwards head tilt *should* increase perceptions of dominance when participants are shown the head with the eyes and eyebrows occluded. I 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 5, preregistered at osf.io/342zs, thus provides a stringent test of the AU-imposter account by testing two conservative predictions derived from it and pitting it against all other accounts.

Method and materials

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.

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 9).

Figure 9. *Stimuli used in Study 5. 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 10).

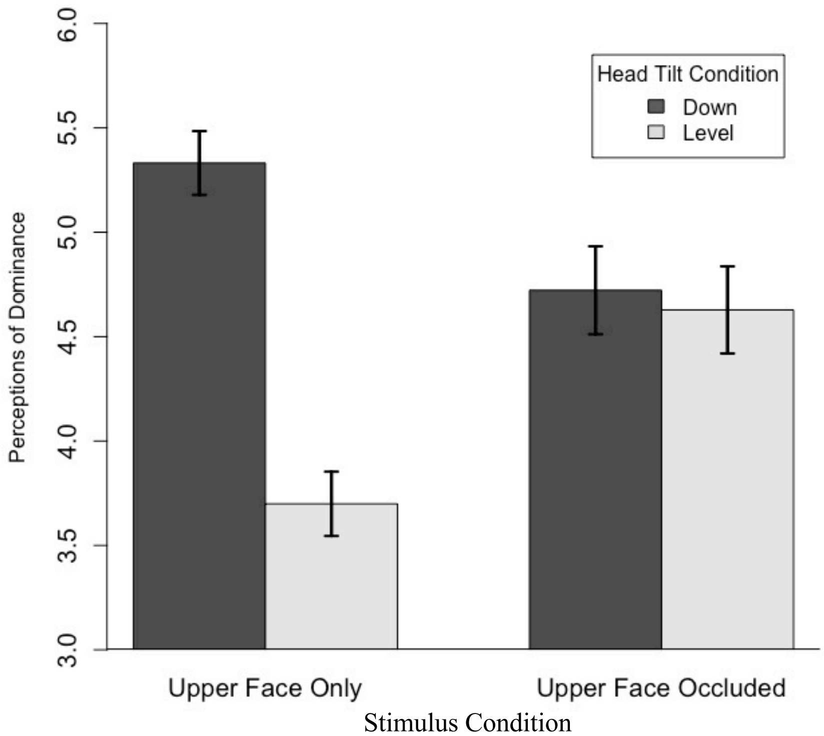


Figure 10. *Mean perceptions of dominance by head tilt and face visibility conditions, Study 5.*
Note. Error bars indicate +/- 1SE from the mean.

Examining the effect of head tilt separately for each stimulus type revealed that, consistent with my 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 10). Also consistent with my 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; I 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 all accounts besides the AU imposter account; even when participants could not perceive the vFWHr, the neck or body, chin size, or lip curvature, they judged the target as more dominant when his head was tilted downward. Similarly, when participants were shown all parts of the face *besides* the eyes and eyebrows, a downwards head tilt was no longer perceived as more dominant. Together, these findings are consistent with my 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 6

Although the results of Study 5 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 or eyeballs 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 my 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 6 (preregistered at osf.io/342zs) I 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 I also conducted a second test of this hypothesis using a different experimental design and a new measure of dominance perceptions.

Method and materials

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 11) in a random order and rated the dominance of each using the same measure as in previous studies.

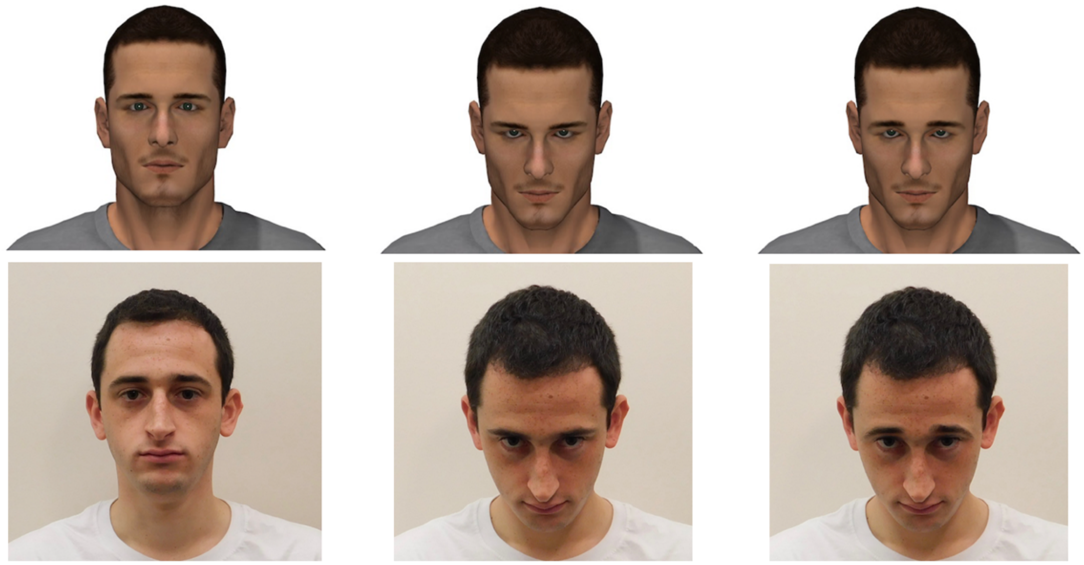


Figure 11. *Stimuli used in Study 6. Avatar (top row) and human (bottom row) displaying a neutral head angle (left column), head tilted downward (middle column), and head tilted downward with eyebrows copied and replaced from the neutral-head tilt condition (right column).*

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., 2020; Witkower, Hill, Pun, Baron, Koster, & Tracy, under review; Witkower, Hill, Koster, & Tracy, 2021). 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, I developed stimuli in which the eyebrows were artificially manipulated independently of head tilt angle. To do so, I 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 11).

Results

To determine whether it would be appropriate to aggregate analyses across targets, I 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, suggesting that the effect of head tilt on perceptions of dominance did not vary by the target being rated. I therefore collapsed across targets in remaining analyses. Consistent with my pre-registered hypothesis, a one-way ANOVA revealed a significant effect of condition on perceptions of dominance (based on ratings 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, *p*s < .001 and >.99, respectively; and avatar: $d = .73$ and -.08, *p*s < .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 12). For effects separated by target, see Figure 13.

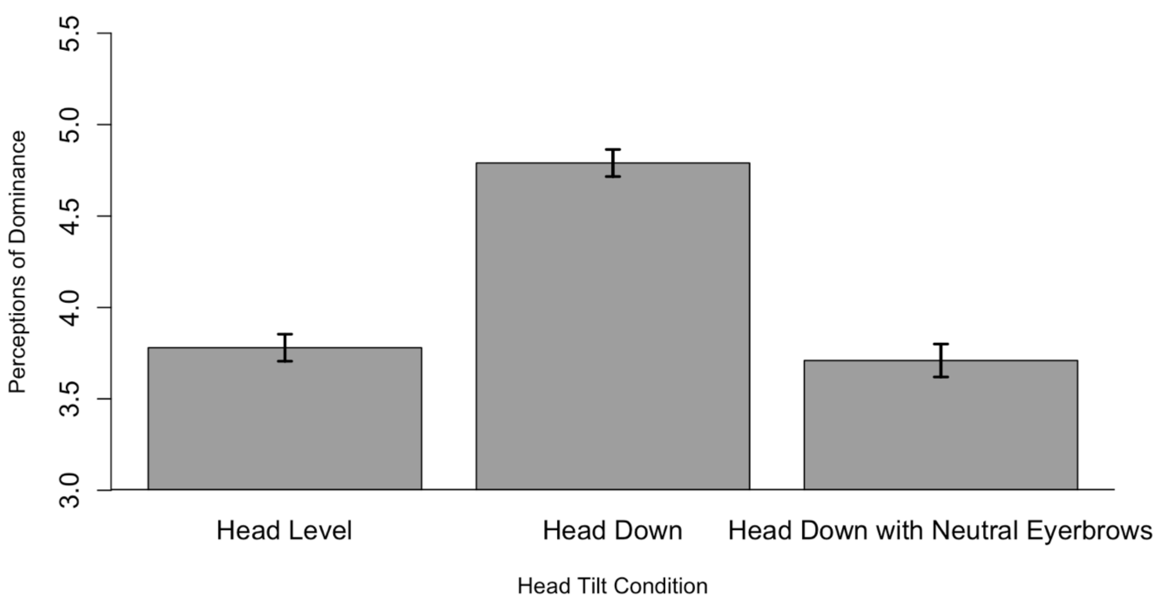


Figure 12. *Mean perceptions of dominance by head tilt and eyebrow alteration condition, Study 6. Note.* Error bars indicate +/- 1SE from the mean.

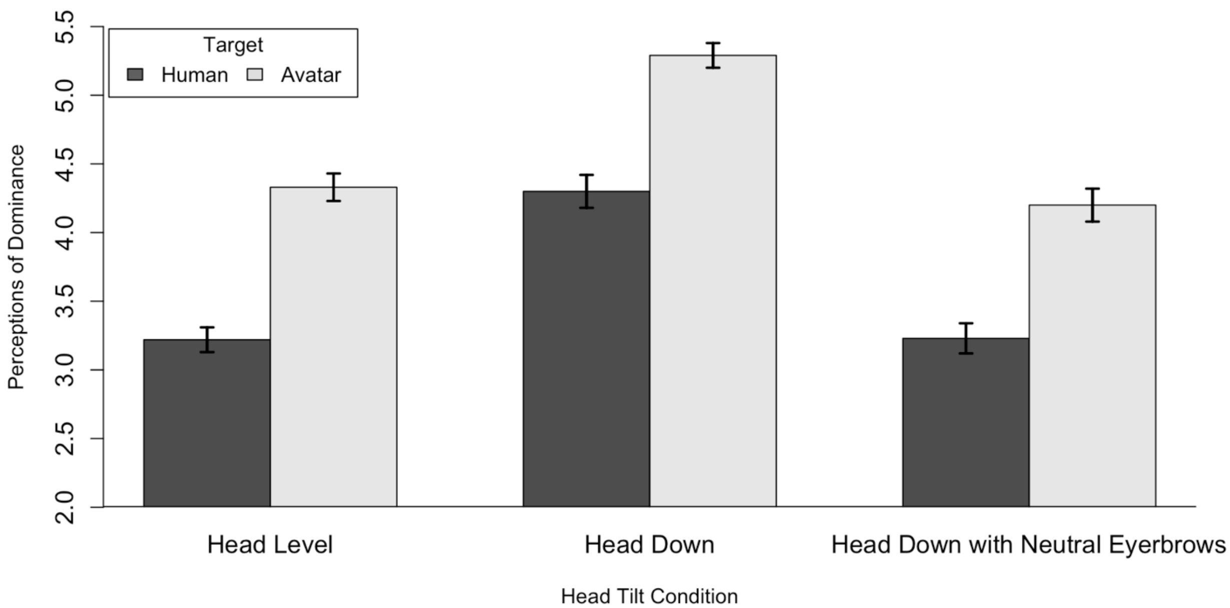


Figure 13. *Mean perceptions of dominance by head-tilt, eyebrow-alteration condition, and target, Study 6. Note.* Error bars indicate +/- 1SE from the mean.

Turning to the forced-choice response item, a series of binomial tests (with chance set at 50%, given that participants selected between 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 my 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 I 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; inner brow raiser; 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.

These findings are inconsistent with previously proposed accounts that aim to explain why a downwards head tilt might increase perceptions of dominance. When the head is tilted down and the eyebrows were adjusted such that they no longer increased in their V-shaped appearance, a downwards head tilt no longer increase perceptions of dominance; this is consistent with the AU imposter account, but inconsistent with previously proposed accounts, including the vFWHr, visibility of the neck, location of the head relative to the body, chin size, and lip curvature, because all other features besides the eyebrows changed in naturally occurring ways, but the resulting expression did not increase perceptions of dominance. Together, these findings are consistent with my 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 7

Like Study 6, Study 7 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 6, 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 6). This led to very unnatural-looking stimuli with odd coloration. Second, 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 6. Third, 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. Therefore, Study 6 is an improved version of this study, but results are nonetheless largely similar across the studies. For pre-registration, see osf.io/342zs.

Method

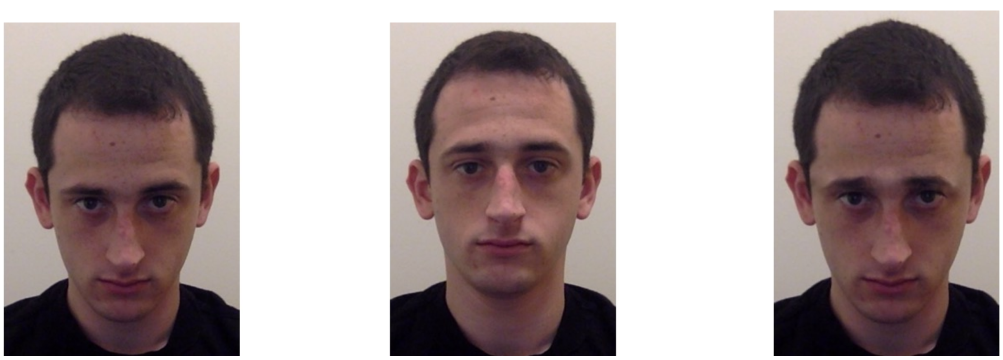
Participants and procedure

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, my 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 my study design ($N = 511$, 3 groups, between subjects), my observed power was 86%, suggesting I likely had sufficient power to detect my 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 14. 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, I developed stimuli in which the eyebrows were artificially manipulated independently of head tilt angle. To do so, I used photographs of one human target displaying a neutral head angle, and tilting his head downward slightly. Using iPhoto, a free photo viewing tool with editing capabilities, 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 6, 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.



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

Figure 14. *Stimuli used in Study 7*

Results

A one-way ANOVA revealed a significant effect of condition on perceptions of dominance, F (2,507) = 25.18, $p < .001$, $\eta_p^2 = .09$. 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 15). These results converge with those of Study 6 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. I am 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 6.

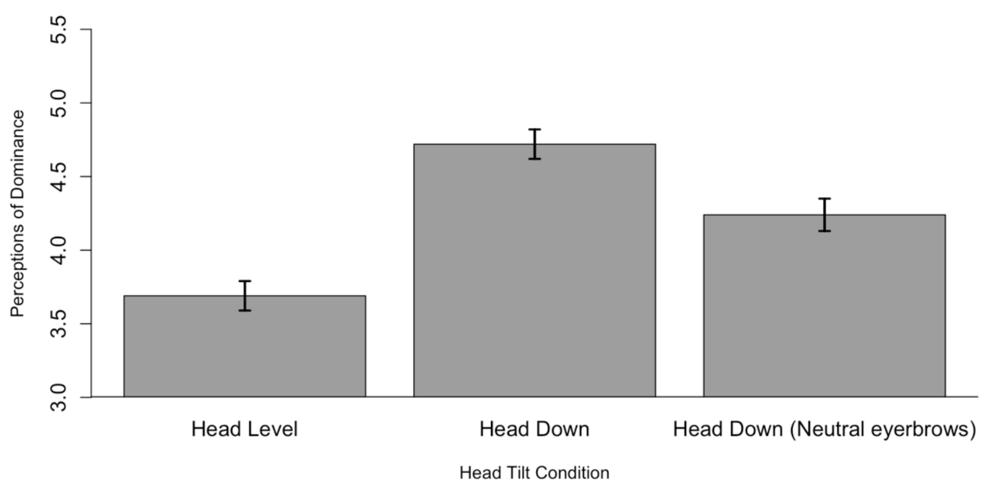


Figure 15. *Mean perceptions of dominance by head tilt and eyebrow alteration condition, Study 7. Note.* Error bars indicate +/- 1SE from the mean.

Study 8

Studies 5, 6, and 7 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 8 tested my hypothesized mediational model using unaltered images.

Method and materials

I 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, I 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; Albohn, & Adams, 2020), 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, I was 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 I recruited or showed images to judges, and before I 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 6: "This person is likely to be a leader because he/she is willing to use aggression and intimidation to get his/her way." I 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 16) "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 my hypotheses pertained to the appearance cues associated with corrugator activation (i.e., AU4), the medial and central parts of the eyebrow was my 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 I 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 17, and the difference between eyebrow V-shape across both conditions is demonstrated in Figure 18.

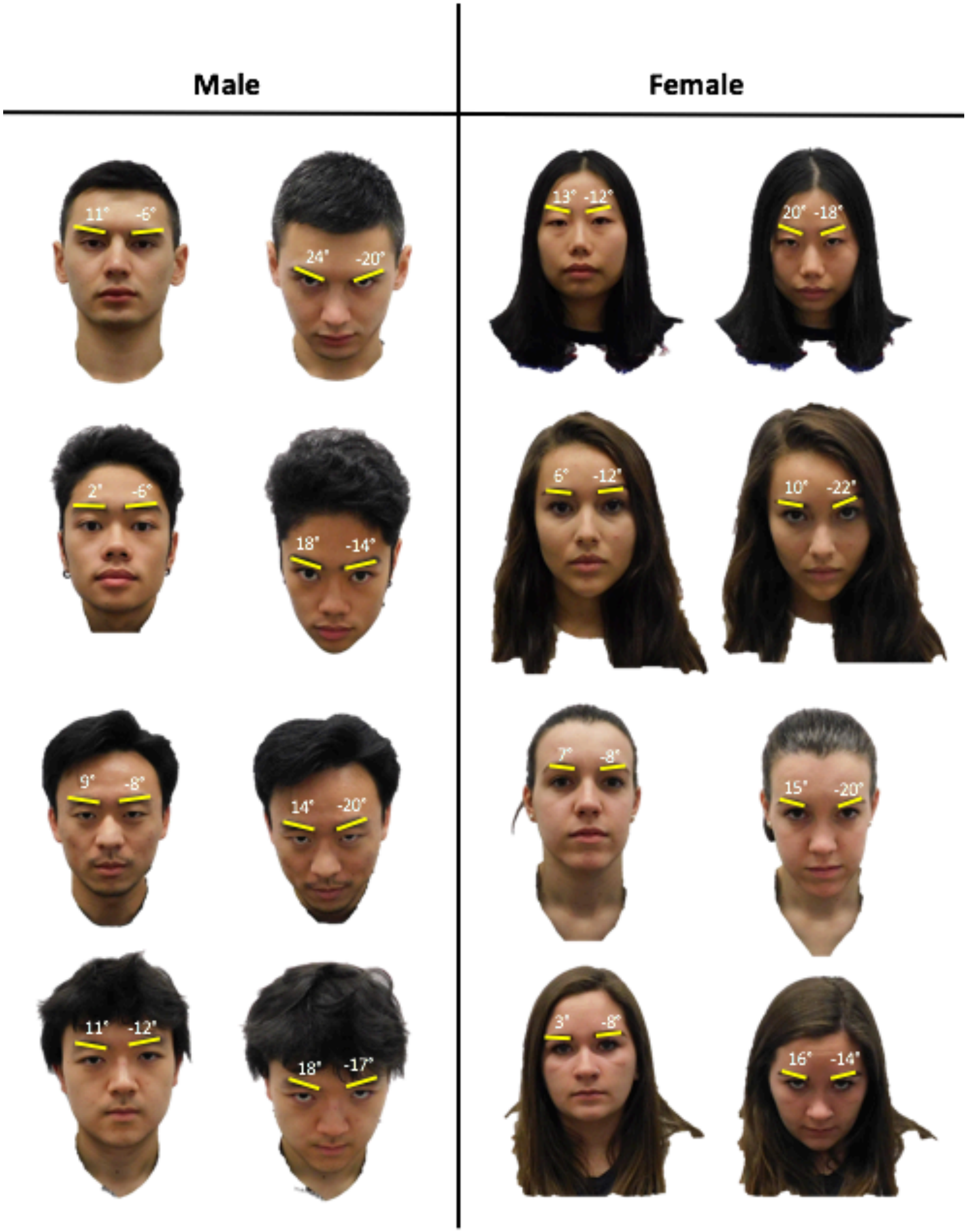


Figure 16. *Examples of eyebrow-angle coded faces, Study 8.*

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 17). This effect remained robust after including random slopes for head-tilt condition and controlling for target ethnicity and gender (see Table 1). As a second test of this effect, A repeated-measures ANOVA was conducted, and 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 18).

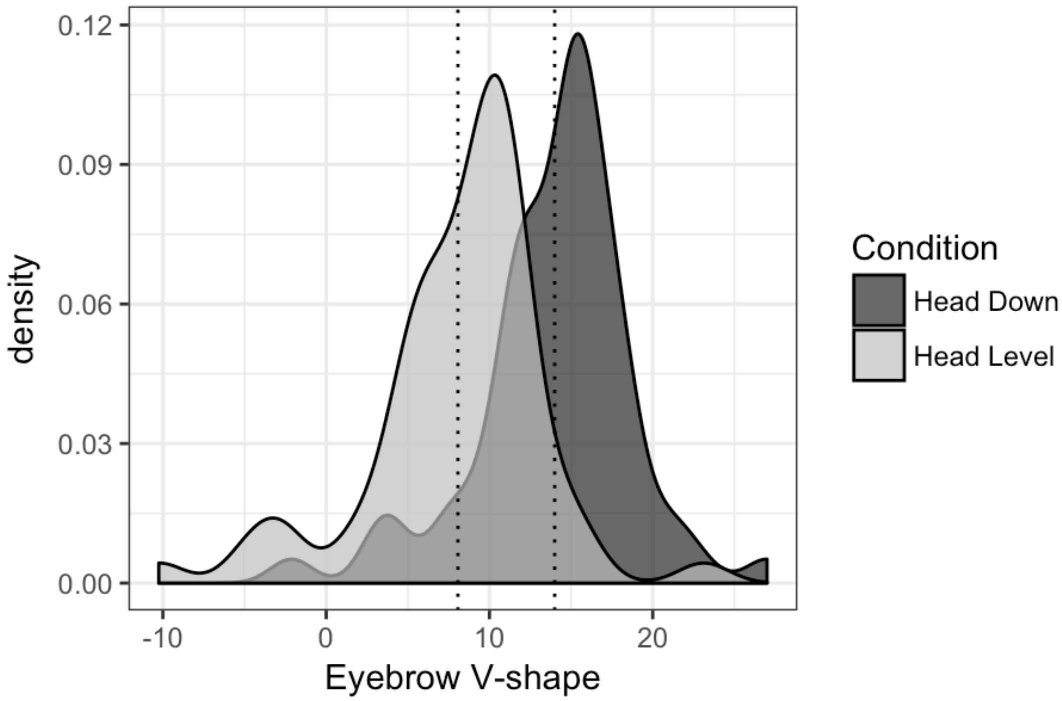


Figure 17. *Kernel density plot visualizing the distribution of eyebrow V-shape angle for all participants in each head-tilt condition, Study 8. Vertical dashed lines indicate the mean for each group.*

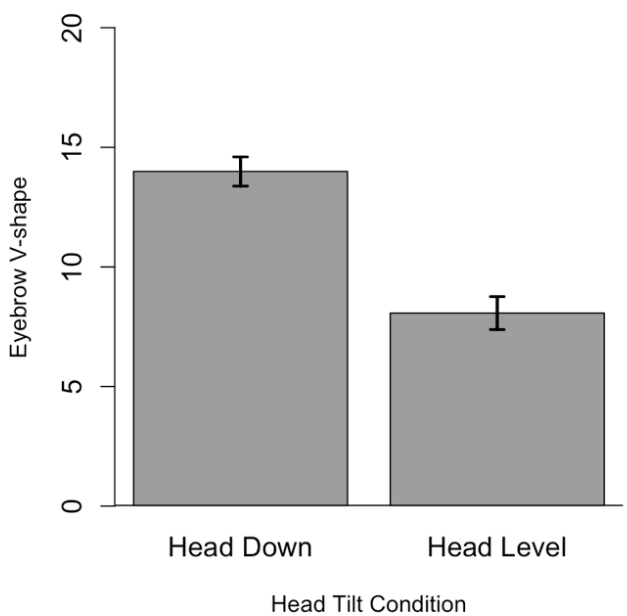


Figure 18. Eyebrow V-shape for targets with their heads level and tilted down, Study 8.

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] (see Figure 19).

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). In sum, the results of Study 8 indicate that tilting the head downward causes the eyebrow angle to take on an apparent V-shape, and V-shaped eyebrows, in turn, are related to increased perceptions of dominance.

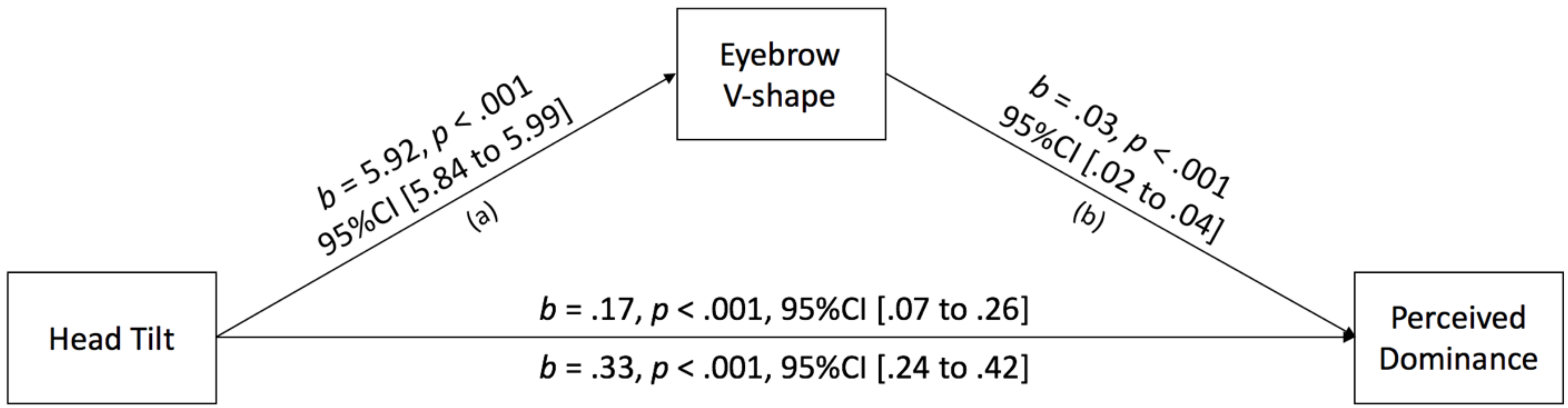


Figure 19. *Effect of manipulated head tilt on perceptions of dominance via changes to the apparent V-shape angle of the eyebrows*

Table 1. Multi-level models indicating that head-tilt angle predicts perceptions of dominance via eyebrow angle, Study 8

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 8.

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 eight studies, I 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, covering the neck, apparent mouth curvature, size of the chin or eyes, 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, in turn, associated with increased dominance perceptions.

These findings also provide the first evidence that head movement guides perceptions by altering 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; Witkower & Tracy, 2020). 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 I 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 my approach quite conservative. Furthermore, these subtle shifts likely correspond to signaling in everyday life, thus increasing ecological validity.

Is the Action Unit Imposter Likely to be a Human Universal?

Over 50 years ago, Ekman and colleagues conducted foundational research demonstrating that facial expressions associated with a small set of emotions are reliably recognized across a range of populations, including traditional small-scale societies that had little to no contact with the Western world (Ekman, Sorenson, & Friesen, 1969; Ekman & Friesen, 1971). Given that the preliterate, culturally isolated participants in some of these studies could not have learned about Western emotion expressions through cross-cultural transmission, these findings are widely considered to be one of strongest pieces of evidence supporting the case for universal emotions, and, more broadly, an evolved human nature (Brown, 1991; Buss, 1992; Pinker, 2003; Henrich, Heine, & Norenzayan, 2010; Norenzayan & Heine, 2005; Witkower & Tracy, 2020).

Building on this seminal work, subsequent cross-cultural research on nonverbal communication has focused largely on facial expressions of emotion, yet nonverbal behaviors beyond the face are also regularly employed in human social interactions, and are used to communicate a variety of emotional and non-emotional messages. For example, studies have identified a distinct, cross-culturally recognized nonverbal display that includes the body as well as the face, and that functions to communicate *dominance* – a form of high social rank associated with the use of aggression and intimidation to elicit fear and forced deference (Witkower et al., under review; Witkower, Tracy, Cheng, & Henrich, 2020). This display features bodily expansion, a neutral facial expression, and a downwards head tilt (Witkower et al., 2020). In North American samples, this display elicits perceptions of dominance even when observers view only the downwards head tilt and neutral face presented in isolation, devoid of any visible facial or bodily movement (Witkower & Tracy, 2019).

To account for the strong signal of dominance sent by a downward-head tilt alone, Witkower and Tracy (2019) proposed the *action unit imposter* account, wherein tilting one's head downward causes the eyebrows to take on an apparent V shape and seem to become lowered—the same appearance cues associated with Action Unit (AU) 4, the "eyebrow lowerer" (i.e., corrugator muscle activity), in Ekman and Friesen's (1978) Facial Action Coding System (FACS). Numerous studies have found that AU4 is associated with facial expressions of dominance, threat, and anger across cultures (Ekman et al., 1987; Ekman & Keltner, 1997 Camras & Allison, 1985; Ekman, 1994; Ekman & Friesen, 1971; Tiedens, 2001; Keating & Bai, 1986), and Witkower and Tracy (2019) found that these same social messages were communicated by a downward-head tilt and neutral face, even though no AU4 activity was present. In other words, by mimicking the appearance cues associated with AU4, tilting one's head downward creates the illusory appearance of this action unit, and thereby conveys a similar social message. In this way, a downward-head tilt serves as an "imposter" of AU4.

Given that lowering one's brow, or activating AU4, is a cross-cultural signal of threat and dominance, and a downwards head tilt causes the same appearance changes as this facial movement, a downwards head tilt might also be a cross-cultural signal of dominance. Prior studies have found that downwards head tilt conveys dominance among North American (Zhang, Lin, & Perrett, 2020; Torrance et al., 2020; Hehman, Leitner, & Gaertner, 2013) and Portuguese (Toscano, Schubert, & Giessner, 2018) populations, but in all of these studies participants were Westernized, Educated, Industrialized, Rich, and Democratic (WEIRD; Henrich et al., 2010). No prior research has tested whether a downwards head tilt communicates dominance across populations that are maximally divergent from WEIRD samples, leaving open the question of whether this behavior might be a universal signal of dominance, and, if so, whether that is because it functions as an AU imposter across human societies—that is, whether this visual illusion is a universal feature of human psychology. Although I expected this effect to generalize across cultures, there is also reason to suspect it might not; other visual illusions, such as the Muller-Lyer effect, which were long assumed to be universal features of human perception, are now known to be a consequence of unique features of WEIRD cultural learning (i.e., in the case of Muller-Lyer, "carpentered corners"; Segall, Campbell, & Herskovitis, 1966; Henrich et al., 2010). It therefore remains an open question whether the AU imposter effect is likely to be a human universal.

Furthermore, if a downward-head tilt is found to increase dominance perceptions across cultures, there are alternative explanations for this effect, beyond the AU imposter account. Previous scholars have suggested that a downwards head tilt might communicate dominance (or related constructs such as threat and intimidation) by changing the apparent dimensions of the head (i.e., facial width-to-height ratio; Hehman et al., 2013), changing the apparent size of the chin (Makhanova, McNulty, & Maner, 2017), making the head and neck appear closed and contracted relative to the body (Rule, Adams, Ambady, & Freeman, 2012), changing the appearance of the mouth (Lyons et al., 2000), or defensively covering the neck with the chin (Hehman et al., 2013). Critically, all of these other visual mechanisms rely on parts of the head and face *besides* the eyebrows, whereas the AU imposter account is based on changes to the appearance of the eyebrows alone. Prior research on the AU imposter mechanism in North America systematically ruled out each of these alternatives (Witkower & Tracy, 2019), but it remains unknown whether these mechanisms might account for any impact of downward-head tilt on dominance perceptions in other cultural contexts.

Study 9

In the present pre-registered research (see here), which is currently under review (Witkower, Hill, Koster, & Tracy, under review), I tested whether a neutral face with a downward-tilted head is perceived as dominant by the Mayangna– members of an unindustrialized, small-scale traditional society in Nicaragua. I further tested whether, if this effect emerged, it is likely to be due to the AU imposter illusion. Addressing these questions in this population has significant theoretical importance, as these individuals exist in a highly divergent cultural context from those examined in previous work on the AU imposter effect, and they are unlikely to have considerable prior exposure to North American culture. As a result, if the Mayangna perceive a downwards head tilt as dominant, it would be highly unlikely that these perceptions are a result of acculturation. Findings along these lines would thus provide strong evidence to suggest that this head movement functions to evoke a universal signal of dominance.

To test whether the AU imposter illusion that accounts for these perceptions in WEIRD samples is also likely to be universal, I also showed participants stimuli featuring the upper face only, with the rest of the face and head visually occluded. If a downwards head tilt increases perceptions of dominance by changing the appearance of the eyebrows (i.e., by serving as an imposter of AU4), participants should perceive a neutral face with a downwards tilted head as dominant even when all other facial and head features besides eyes and eyebrows are hidden—that is, when even the head tilt itself is not visible. In contrast, if a downwards head tilt increases perceptions of dominance by changing the appearance of the jaw, mouth, or facial height, or by contracting the head to cover the neck or bring it closer to the body, this behavior would *not* increase perceptions of dominance compared to a neutral head angle when participants view only the eyes and eyebrows in isolation. Therefore, by restricting visible stimuli to the narrow band of the face where the eyes and eyebrows are located, I can test whether the AU imposter mechanism operates cross-culturally, while pitting it against all other previously proposed visual mechanisms.

I preregistered two hypotheses: (1) among the Mayangna, a neutral face with downwards head tilt will increase perceptions of dominance compared to the same facial expression with a neutral head angle, and (2) this effect will emerge in this population even when the eyes and eyebrows are shown in isolation (https://osf.io/sev3x/?view_only=9e3fdc9764774c08b7b9e2a3c27f8c11).

Method

Participants

The Nicaraguan community sampled for this research was comprised of indigenous Mayangna horticulturalists living primarily in the forested region of the Bosawas Biosphere Reserve (Winking, Eastwick, Smith, & Koster, 2018; Koster, 2018; Sznycer et al., 2018; Koster, Grote, & Winterhalder, 2013). I aimed to recruit as many members of this community as possible; ultimately the sample included more than approximately 90% of the adult members of the community: 119 individuals (65 female) who ranged from age 18 to 75 (*M* age = 34.23; *SD* age = 14.62). Only a small proportion of my sample had been exposed to westernized media or technology (internet = 6%, US Movies = 29%, US Television = 16%). Only 16% indicated that they could read and write fluently in Spanish – the national language of Nicaragua. Participants had little formal education (*M* = 5.97 years, *SD* = 4.15 years) and minimal exposure to western media (73% had never seen a US movie, 84% had never seen a US television program, and 79% had never used the internet).

All participants completed the present study after first participating in two separate studies, one examining recognition of dominance and prestige displays from full-body images (Witkower et al., under review), and the other examining emotion recognition (i.e., anger, fear, sadness) from body-only (i.e., face occluded) images (Witkower et al., 2021). As a result, prior to participating in the present study, these individuals had viewed other stimuli featuring a downwards head tilt as part of the dominance display. In both prior studies, however, displays were posed by human targets instead of a computer-generated avatar, so participants never saw the images presented here outside of this study. Although it is nonetheless possible that carry-over effects could influence results in the present study (e.g., participants might recall seeing full-body dominance displays and use the judgment they made in viewing them to infer dominance from the head-only images shown here), I see this possibility as unlikely, given how different the stimuli in both other studies were from those used here (i.e., in addition to being actual human posers, targets used in prior studies varied in ethnicity and gender; and in all prior study images, full bodies were shown rather than head or face only). Furthermore, across all three studies participants completed a total of 78 trials, comprised of comparisons among 28 different images, thus reducing the likelihood that they would remember their response to any particular image seen previously.

Given my goal of recruiting individuals who are unlikely to possess considerable knowledge about Western culture, I first endeavored to assess participants' familiarity with global popular culture by asking them to identify images of 13 highly recognizable cultural icons: Donald Trump, Barack Obama, Hillary Clinton, Oprah Winfrey, Will Smith, Brad Pitt, Taylor Swift, Lebron James, Lionel Messi, Cristiano Ronaldo, Michael Jordan, Elvis Presley, and Abraham Lincoln. To assess participants' exposure to the culture of industrialized Nicaragua, I also showed them an image of Daniel Ortega, the current President of Nicaragua who served as head of state in non-concurrent terms for 22 of the 40 years preceding data collection. For each image, participants were asked "Who is this?" and responded aloud in an open-ended fashion. On average, participants correctly identified fewer than one of the 13 popular cultural icons (M= 0.54 images, SD = .86, Mode = 0; Range = 0 to 3), and 67% correctly identified Ortega. Together, these results suggest that participants had minimal exposure to western culture.

Materials

A computer-generated male avatar created in past research (Witkower & Tracy, 2019) was used in the current study. Using an avatar allowed us to precisely manipulate the target's head angle while preventing any incidental facial movements. The avatar was portrayed with his head at a neutral angle (0°) and tilted down (10°), with eye gaze directed towards participants in both images (see Figure 20). Although a 10-degree tilt is somewhat subtle, this small behavioral change has been found to effectively promote perceptions of dominance in prior work (Witkower & Tracy, 2019), and is consistent with the kinds of behaviors that tend to occur during real-life social interactions. Participants viewed the neutral angle and downward-head tilt version of the avatar, side by side, twice, once with the avatar's entire head visible, and once with his upper face only visible (i.e., the narrow band from the cheekbones to the brow ridge, excluding the forehead and mouth; see Figure 20).

Figure 20. Neutral head angle (left) and downward-head tilt (right) stimuli, with the whole head visible (top), and the upper face visible with the rest of the face and head occluded (bottom).

Procedure

In each of two trials, participants were shown two images side-by-side, contrasting a neutral head angle with a downwards head tilt (with eye gaze directed towards the observer in both cases). In the first trial, participants viewed the stimuli featuring the upper face only (i.e., eyes and eyebrows in isolation), to test whether changes to the appearance of the eyes and eyebrows, as per the AU imposter mechanism, are responsible for any effect of downward-head tilt on perceived dominance. In the second trial participants viewed the whole head, to test whether a downward-head tilt is sufficient to communicate dominance with no additional bodily information available. By ordering the trials in this manner, I ensured the 'whole head' stimuli did not influence perceptions formed from the upper face alone.

For each trial, participants were asked: "Please select the image in which the person is likely to be a leader because he is willing to use aggression and intimidation to get his way". An English version of this prompt was previously validated to reliably assess dominance in U.S.

samples (see Witkower et al., under review; Witkower & Tracy, 2019). All materials were translated from English to Spanish (and back-translated from Spanish to English) prior to the study, and then translated from Spanish to the Mayangna and Miskito languages on-site by a colleague, Jeremy Koster, and two research assistants fluent in Spanish, Mayangna, and Miskito (for original materials in English, Spanish translations of those materials, and Spanish-to-English back-translations, see Witkower et al., under review).

Results

In line with my pre-registered analysis plan, two binomial tests were conducted to test whether participants selected the downward-head tilted version of each expression as the more dominant image at rates significantly greater than chance (i.e., 50%, given that participants selected between two images). Consistent with my hypotheses, in both trials participants identified the image featuring a downwards head tilt as significantly more dominant than the image with a neutral angle head; for full-head images, 84%, $p < .001$, 99.99% CI [.76 to .90]; for upper-face only images, 72%, $p < .001$, 99.99% CI [.63 to .80] (see Figure 21). These two rates differed significantly, $X^2(1) = 4.16$, $p = .04$, suggesting that the information provided by the presentation of full head contributed slightly to dominance perceptions beyond what was gleaned from the upper face only. However, the improved rates could also be due to order effects; participants might have become more confident in their perceptions of dominance upon seeing the critical image for a second time (immediately after the first), given that the full-head image contained all of the visual information present in the upper-face only image.

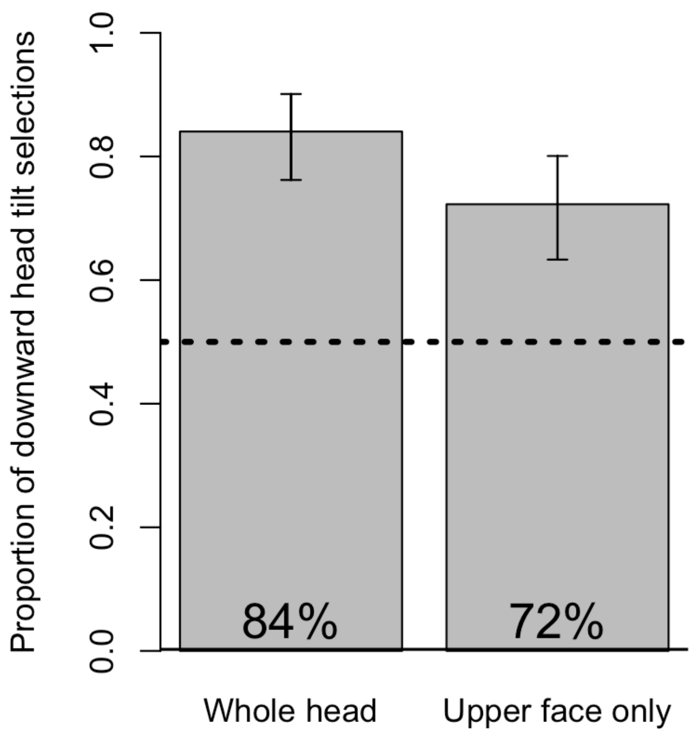


Figure 21. Proportion of downward-head tilt selections in response to the dominance prompt, when participants were shown the whole head (left), and the upper face in isolation (right).

Exploratory analyses

As a more stringent test of my hypothesis, I next analyzed data only for those participants who failed to recognize *any* of the 13 global icons, and also failed to recognize the current President of Nicaragua, who served as head of state in non-concurrent terms for 22 of the 40 years preceding data collection. This subsample, which I refer to as the *highly isolated* subsample, consisted of 36 individuals (25 female, *M* age = 37.86 years; *SD* = 16.89 years).

Consistent with findings from my prior pre-registered analyses, participants in the highly isolated subsample identified images featuring a downwards head tilt as more dominant than images featuring the neutral head angle, when viewing the full head, 78% $p < .001$, 99.99% CI

[.61 to .90], and when viewing the upper face only, 69%, $p < .001$, 99.99% CI [.52 to .84]. These two rates did not differ significantly, $X^2(1) = 0.29$, $p = .59$.

General Discussion

The current study demonstrates that a downwards head is sufficient to communicate dominance among the Mayangna, and that this effect is due, at least in part, to changes in the appearance of the upper face caused by the action-unit imposter mechanism (see Chapter 1). The current research therefore provides the first evidence to suggest that humans across highly diverse cultural contexts perceive dominance from a downwards head tilt alone, and that the action-unit imposter mechanism might be a universal visual illusion that contributes to these perceptions. It is noteworthy that the rate at which participants identified the downwards tilted-head image as dominant was greater when they viewed the whole head, compared to when they were shown only the upper face. This small but significant difference could suggest that additional features of the head, including the mouth, nose, and chin, contribute to perceptions of dominance formed from a downwards head tilt, in this population. However, because participants always viewed the full head image after the upper-face only version, it is also possible that increased dominance perceptions were due merely to repetition and learning. Future research is needed to determine whether additional features of the head contribute to perceptions of dominance formed from a downwards head tilt among the Mayangna, and, if so, whether these features' role in shaping the social message conveyed by this display is specific to this population.

The present findings also rule out the possibility that several alternative mechanisms put forward previously might be primarily responsible for perceptions of dominance formed from a downwards head tilt among the Mayangna. In particular, by showing that these effects emerge when only the upper face is visible, the present findings rule out the possibility that the impact of downward-head tilt on dominance perceptions is due to: (1) changes to the visible facial width-to-height ratio (i.e., Hehman et al., 2013); (2) changes in the apparent size of the chin and eyes (Makhanova et al., 2017); (3) changes to the appearance of the mouth (the Noh Mask; Lyons et al., 2000; Mignault & Chaudhuri, 2003); (4) becoming more closed and contracted (Rule et al., 2012); or (5) covering the neck with the chin (Hehman et al., 2013).

Nonetheless, the present research did not rule out the possibility of visual mechanisms that alter upper face appearance, in addition to the AU imposter mechanism, such as apparent changes to the sclera or eyeballs. Prior research has ruled out this alternative mechanism in North American samples (see Chapter 2 of this dissertation), but future studies are needed to address this possibility in a non-WEIRD population, to more fully support the universality of the AU imposter effect.

In sum, the current research provides the first evidence that a downwards head tilt is sufficient to communicate dominance among the Mayangna –members of an unindustrialized small-scale traditional society, who have minimal exposure to North American culture. Furthermore, this effect appears to be due, at least in part, to changes in the appearance of the upper face likely caused by the AU imposter illusion (Witkower & Tracy, 2019). Although past research has demonstrated that facial and bodily expressions of emotion and social rank generalize across cultures and ages (e.g., Witkower, Tracy, Pun, & Baron, in press; Witkower, Hill, Koster & Tracy, under review; Witkower, Hill, Pun, Baron, Koster, & Tracy, under review; Tracy & Robins, 2008; Ekman et al., 1987; Ekman & Friesen, 1971; Ekman, Sorenson, Friesen, 1969), no prior research has tested whether the visual mechanisms that humans use to guide such perceptions might be universal. The present research is thus the first to demonstrate that the cognitive mechanism underlying the communication of a major status signal is likely to be a universal feature of human social signaling.

How and why the action unit imposter changes the perception of facial expressions of anger

Facial expressions play a crucial role in the communication of emotional information (Ekman & Oster, 1979; Ekman, 1993; Ekman & Rosenberg, 1997), but they are almost never perceived in isolation. Instead, observers view these expressions as they rest upon their physical foundation: the head. Prior research has shown that head tilt (i.e., head pitch rotation upward or downward) may also play a role in emotion communication, as it can influence the perception of a variety of emotion expressions from the face. For example, an upwards head tilt increases the recognition of positive facial emotion expressions, including happiness, amusement, and pride (Witkower & Tracy, 2018; Tracy & Robins, 2004; 2007; Cordaro et al., 2019; Livingstone & Palmer, 2016). In contrast, a downwards head tilt increases recognition of negative emotion expressions including sadness and shame (Witkower & Tracy, 2019a; Tracy, Robins, & Schriber, 2009; Toscano, Schubert, & Giessner, 2018; Keltner, 1995; Keltner & Buswell, 1997; Livingstone & Palmer, 2016; Mignault & Chaudhuri, 2003; Witkower & Tracy, 2019b).

Head tilt has also been found to influence perceptions of social rank and personality; an upwards head tilt can convey superiority and *prestige* – a form of high rank characterized by warmth and the receipt of admiration and respect (Witkower, Tracy, Cheng, & Henrich, 2019; Mignault & Chaudhuri, 2003), and a downwards head tilt—when eye gaze is directed towards observers—conveys intimidation and *dominance* – a form of high rank characterized by aggression and threat (see Chapter 2; also see Witkower & Tracy, 2019a; Hehman, Leitner, & Gaertner, 2013; Toscano et al., 2018; Witkower, Tracy, Hill, Pun, & Baron, in prep; Witkower et al., 2019a; Torrance; Holzleitner, Lee, DeBruine, & Jones, under review; Tracy, Mercadante, Witkower, & Cheng, 2020). Together, these findings suggest that tilting one's head upwards increases perceived positive emotion and affiliation, whereas tilting one's head downwards increases perceived negative emotion and antisocial or threatening intentions.

Although these effects are well documented, only recently have studies begun to examine the visual mechanisms that account for them (see Chapter 2). Most notably, the effects of downward head tilt on perceptions of dominance from a neutral face have been explained by the *action-unit imposter* account: tilting the head downward causes one's eyebrows to appear to lower and take on a V-shape, the same appearance changes that occur from activation of the corrugator muscle, or Action Unit 4 (AU4; Ekman, Friesen, Hager, 2002). Corrugator activation is, in turn, associated with anger and threat across cultures (Ekman et al., 1987; Tracy & Robins, 2008). Tilting the head downward while the face remains neutral and eye gaze is directed forward therefore leads to anti-social perceptions of threat, intimidation, and dominance by mimicking appearance cues – V-shaped eyebrows – that are associated with similar threat signals caused by facial muscle activity (see Chapter 2).

The action-unit imposter effect has thus far been found to influence social perceptions of neutral faces, but the account has interesting implications for facial expressions of emotion. Given that both head movements and facial muscle activation affect social perceptions by changing the appearance of the face, these two sets of behaviors may, at times, interfere with one another to alter the way that facial expressions are perceived. Yet the muscles responsible for head pitch rotation (Longus Capitis, Longus Colli, Sternocleidomastoids, and Trapezius) are located in the neck and the back – not in the face. As a result, although shifts in head angle change the appearance of the face, head tilt cannot be considered a facial expression: it does not involve facial muscle activity. What this suggests, then, is that if head tilt influences perceptions formed from facial expressions of emotion, tilting one's head might cause a facial expression of emotion to take on a different appearance and consequently communicate a different message, even while observers' perceptions are based on information that is apparent only in the face.

In particular, because a downwards head tilt leads to perceptions of threat or dominance, a facial expression of emotion paired with a downwards head tilt might be perceived as more antisocial than whatever emotional message would be conveyed by its facial muscle movements alone. If this is the case, tilting one's head downward might change the message sent by a given emotion expression in ways that vary by the particular facial expression. For an emotion expression like anger, which is already antisocial, the addition of a downwards head tilt might increase the perceived intensity of the anger message. Given that anger expressions include V-shaped eyebrows from corrugator activation, a downwards head tilt should artificially inflate the apparent intensity of corrugator activation by further increasing the apparent V-shape of the eyebrows, which should, in turn, increase the perceived intensity of the anger expression.

For a less anti-social, or even pro-social, emotion like happiness, the addition of a downward head tilt might completely shift the way the expression is interpreted, such that it no longer communicates a pro-social message. Pro-social or positive emotion expressions do not include V-shaped eyebrows from corrugator activation, so adding a downwards head tilt would introduce appearance cues that are atypical of the emotion being expressed, which should decrease the perceived intensity of the emotion. In other words, adding a downward head tilt should increase the perceived intensity of anger expressions, but decrease the perceived intensity of expressions that are not antisocial and do not typically include V-shaped eyebrows, such as happiness, surprise, fear, and neutral.[2]

Research Overview

The current published research (Witkower & Tracy, 2020) consists of four studies (two of which were pre-registered; https://osf.io/8rhwb) testing several hypotheses regarding the ways in which tilting one's head downward systematically changes the perception of facial expressions of emotion. I predicted that a downward head tilt would (a) increase perceptions of anger formed from an anger facial expression, and that this effect would be attributable to the increased appearance of V-shaped eyebrows; but (b) decrease the perceived intensity of emotion expressions that do not include V-shaped eyebrows from corrugator activation (i.e., fear, happiness, surprise, neutral). Together, these studies are the first to test how and why head movement can shift the messages sent by facial expressions of emotion.

Study 10

In Study 10 I tested whether a downwards head tilt would increase the perceived intensity of anger but decrease the perceived intensity of other emotions. Based on the action-unit imposter account, I predicted that emotion expressions that do not include V-shaped eyebrows due to corrugator activation–- in particular, surprise, fear, neutral, and happiness – would be perceived as a less intense when paired with a downward head tilt, given that this movement creates the artificial appearance of corrugator activity, or V-shaped eyebrows, which is uncharacteristic of these emotion expressions.

For disgust, my hypotheses were more exploratory. Although disgust does not prototypically include V-shaped eyebrows from corrugator activation, it does include activation of AU9 (levator labii superioris, alaeque nasi), which can cause the eyebrows to take on a V-shape. However, AU9 is associated with several appearance cues in addition to those in the eyebrows, and these cues emerge predominately around the nose (e.g., pulling the skin alongside the nose upward, raising the infraorbital triangle, widening nostril wings), and mouth (e.g., pulling the center of the upper lip upwards; Ekman, Friesen, & Hagar, 2003). Given that tilting the head down alters perceptions by changing the V-shape appearance of the eyebrows but not of the nose or mouth (Witkower & Tracy, 2019a), it is likely that this head movement distinctively mimics the appearance of AU4 and not AU9. If this is the case, tilting one's head downward should increase the perceived intensity of an anger facial expression but not of a disgust facial expression. However, because AU9 does promote an eyebrow V-shape, it is also possible that a downwards head tilt might mimic the appearance cues of both AU4 and AU9, and consequently increase the perceived intensity of both anger and disgust.

All of these hypotheses were pre-registered at https://osf.io/8rhwb along with the method, sample size, and analysis plan.

Method and Materials

Participants

One-hundred, sixty adults from Amazon Mechanical Turk participated in the current study; 14 of these failed an attention check and were not included in analyses, resulting in a final sample of 146 participants (46% male; age range = 19 - 66, Median = 33 years). This sample exceeded the sample size necessary to uncover a moderate sized effect (i.e., 65%) based on my pre-registered power analysis using an alpha of .05 and 80% power, and chance set at 50%.

Procedure

Participants completed seven randomly ordered trials in which they were shown two images side-by-side of the same facial expression: neutral, happiness, fear, anger, surprise, and disgust. In one of the two images, the head was positioned at a neutral angle, and in the other the head was tilted down roughly 10-15 degrees. For each pair of images, participants were asked to select the more intense version of the emotion that corresponded to the displayed expression, such that they selected the image in which the person was experiencing more intense “surprise”, “anger”, “disgust”, “fear”, “happiness”, and “calmness” (neutral).[3] I elected to use the word “calmness” instead of “neutral” to describe the neutral expression, to avoid asking participants to select an image in which someone was experiencing “more intense neutral”. This approach is consistent with prior studies that have considered responses of both “calm” and “neutral” to be accurate identifications of neutral expressions (Tottenham et al., 2009).

Stimuli

Six emotion expressions were posed and subsequently FACS coded by the first author, who is certified in the Facial Action Coding System: neutral (AU 0; no identifiable facial movement), surprise (AUs 1+2+5+25+26), anger (AUs 4+5+7+23), happiness (AUs 6+7+12)[4], disgust (AUs 9+10+25+26), and fear (AUs 1+2+4+5+20+25)[5]. Each expression was posed with the head at a neutral angle, and then again with the head tilted down and eye gaze directed toward the camera (i.e., the addition of AUs 54+63). All photographs featured a male target in his mid 20s wearing a white shirt. Several photographs were taken for each expression until the expressions adequately matched prototypes from past research (Ekman, Friesen, Hager, 2002, Langner et al., 2010; Olszanowski et al., 2015). All expressions, along with FACS codes for each image, are shown in Figure 22.

Figure 22. *FACS-coded emotion expressions, with the head at a neutral angle (left) and head tilted down (right), Study 10.*

Results and Discussion

Seven binomial tests were conducted to assess whether participants selected the downward-head tilted version of each expression as the more intense version of that expression at levels greater than chance (i.e., 50%). To account for multiple comparisons, highly conservative 99.99% CIs were constructed around all estimates. As hypothesized, the anger expression was selected as conveying more intense anger when the head was tilted down compared to at a level angle, 83%, $p < .001$, 99.99% CI [.69 to .93]. Also consistent with my hypotheses, the surprise expression was perceived as less intense surprise when the head was tilted down, 11%, $p < .001$, 99.99% CI [.04 to .24]; the fear expression was perceived as less intense fear when the head was tilted down, 26%, $p < .001$, 99.99% CI [.13 to .42]; the neutral expression was perceived as less calm when the head was tilted down, 7%, $p < .001$, 99.99% CI [.01 to .19]; and the happiness expression was selected as less intense happiness when the head was tilted down, 15%, $p < .001$, 99.99% CI [.06 to .30]. Finally, supporting the expectation that head tilt downward mimics AU4 but not AU9, the disgust expression was perceived as less intense disgust when the head was tilted down, 30%, $p < .001$, 99.99% CI [.17 to .47]; see Figure 23. In sum, these results supported my pre-registered hypotheses: a downwards head tilt increased the perceived intensity of the anger expression, but decreased the perceived intensity of other expressions that do not include V-shaped eyebrows from corrugator activation (i.e., fear, surprise, neutral, disgust, and happiness).

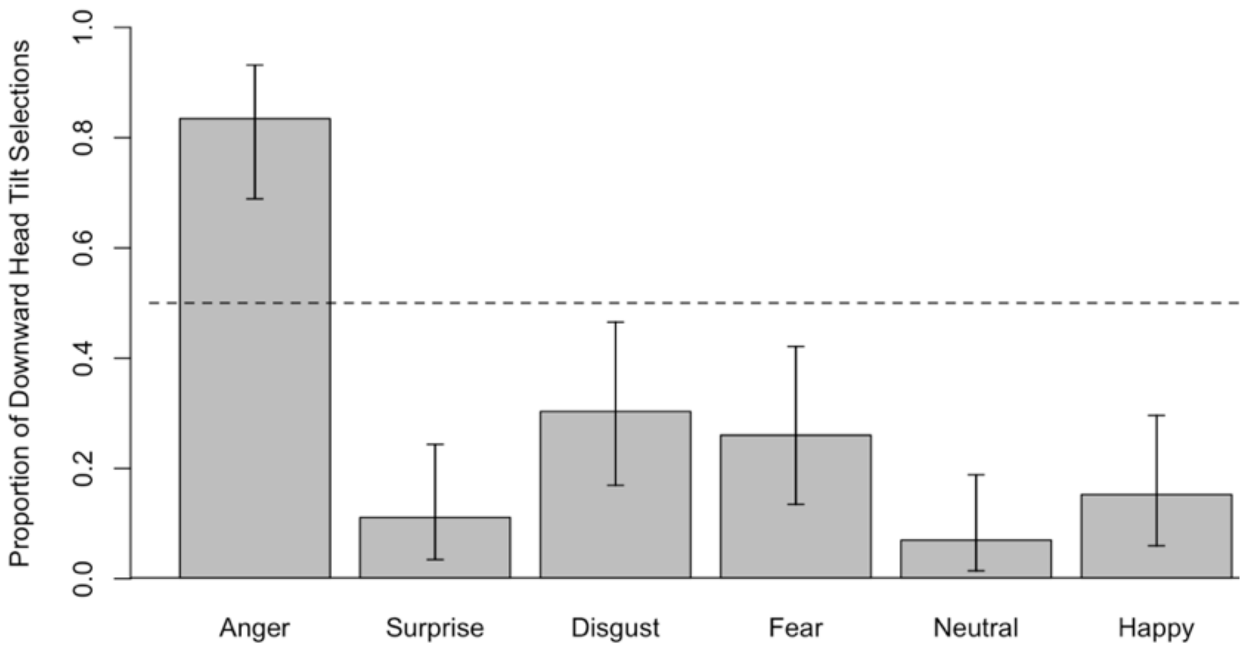


Figure 23. *Proportion of downward head tilt selections for each emotion expression. Error bars illustrate 99.99% CIs. Horizontal dashed line indicates chance level for each comparison (50%).*

Study 11

In Study 11, I tested my mechanistic explanation for the observed effect of downward head tilt on perceived intensity of anger expressions by manipulating the proposed visual mechanism: changes to eyebrow V-shape appearance (Witkower & Tracy, 2019a). First, to replicate the effect uncovered in Study 10, participants were shown a prototypical anger facial expression paired with either a downwards head tilt or a head at a neutral angle, and asked to select the more intense anger expression. Next, to test whether the action-unit imposter effect (i.e., the artificial appearance of eyebrows lowering and taking on a V-shape, caused by a downward head tilt) is the visual mechanism responsible for any observed effect, I examined whether a downwards head tilt would have a similar effect on perceptions of anger expressions when the critical hypothesized cue (i.e., eyebrow appearance) was methodologically held constant. If my mechanistic account is correct, a downward head tilt should *not* increase the perceived intensity of an anger expression if eyebrow shape and angle are held constant while the head is tilted downward (see Witkower & Tracy, 2019). In other words, I hypothesized that visual changes to the eyebrows are necessary for a downwards head tilt to increase perceptions of anger. I therefore pre-registered the prediction that a downwards head tilt would increase the perceived intensity of anger formed from an anger facial expression, but would not have this effect when the head was tilted down but the eyebrows were artificially manipulated so as to not take on an increased V-shape.

To further test this mechanistic account, I also examined whether manipulating *only* the critical hypothesized cue (i.e., eyebrow appearance changes) would increase the intensity of perceived anger, even if the head is *not* tilted downward. Findings in support of this prediction would suggest that the increased intensity of perceived anger from an anger expression paired with a downward head tilt cannot be attributed only to the observation of head movement, but instead must be at least partly due to this movement's impact on facial appearance. In other words, I hypothesized that changes to the appearance of the eyebrows caused by a downwards head tilt would be sufficient to increase the perceived intensity of anger expressions—even if head tilt is not visible.

I pre-registered all of these hypotheses, along with the method, sample size, and analysis plan at https://osf.io/8rhwb.

Method

Participants

Two-hundred, fifty-nine adults from Amazon Mechanical Turk participated in the current study; eight of these failed an attention check and were not included in analyses, resulting in a final sample of 251 participants (49% male; age range = 18 - 71, Median = 33 years). This sample exceeded the sample size necessary to uncover a small effect, based on my pre-registered power analysis using an alpha of .05, 80% power, a moderate selection proportion (60%), with chance set at 50%.

Stimuli and Procedure

Participants completed six trials in which they were shown two images side-by-side, and asked to select the image in which the target individual was experiencing more intense anger. All images were derived from the anger expressions generated for Study 10, which were posed and FACS coded by the first author, who is certified in the Facial Action Coding System. These six trials allowed us to compare judgments of four different images, featuring: a prototypical anger expression (Image A; AUs 4+5+7+23), a prototypical anger expression with the target's head tilted downward while maintaining eye gaze directed forward (Image B; AUs

4+5+7+23+54+63), a prototypical anger expression with the head titled down and eye gaze forward, and eyebrows replaced with those from the image where the target held his head at a neutral head angle (Image C; eyebrow replacement was performed with Adobe photoshop), and a prototypical anger expression with the head at a neutral angle and eyebrows replaced with those from the image where the target held his head downward (Image D). Images were edited by a graphic artist, blind to hypotheses, who ensured that replaced eyebrows appeared compatible with the face they were superimposed onto.[6]

In all primary comparisons, Image A was used as a baseline prototypical anger expression. By comparing Image A with Image B (prototypical anger with head tilted down), I was able to test whether a downwards head tilt increases the perceived intensity of an anger expression. By comparing Image A with Image C (prototypical anger expression with head tilted down and eyebrows identical to those in Image A), I was able to test whether a downwards head tilt increases the perceived intensity of anger even if the eyebrows are held constant across both images (i.e., not permitted to take on the apparent V-shape they naturally do when the head is tilted downward); in other words, whether other appearance cues caused by downward head tilt, besides the eyebrows, might contribute to the effects of this movement on anger perceptions. Finally, by comparing Image A to Image D (identical to image A except that the eyebrows were identical to those in Image B, where the head was tilted down), I could test whether the change in eyebrow appearance caused by downward head tilt is sufficient to increase the perceived intensity of an anger expression, even when the head is not tilted. Together, these comparisons address the question of whether appearance changes to the eyebrows are necessary and sufficient for a downwards head tilt to increase perceptions of anger.

Although I was primarily interested in only these three comparisons, participants made all possible comparisons between all images, so that my hypotheses were less obvious to them. The three pre-registered trials of interest were randomly intermixed among the additional trials. This study was approved by the Behavioral Research Ethics Board (BREB) at the University of British Columbia, under the application H07-02274.

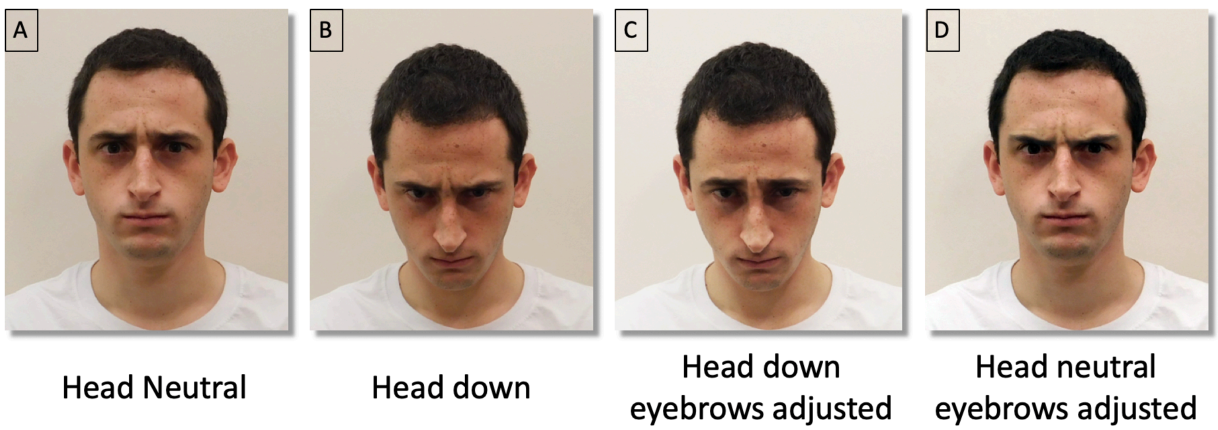


Figure 24. *Four images used in Study 11. All four feature a prototypical anger facial expression, with the head at a neutral angle (Image A), the head tilted down (Image B), the head tilted down and eyebrows superimposed from Image A (Image C), and the head at a neutral angle and eyebrows superimposed from Image B (Image D). For primary pre-registered analyses, anger perceptions made from Images B, C, and D were compared with those made from Image A.*

Results

Primary pre-registered analyses

Three binomial tests were conducted to assess which expression was perceived as a more intense version of anger at levels greater than chance (i.e., 50% because in each trial participants selected one of two images).

Replicating the results of Study 10, the anger expression with a downwards head tilt was perceived as more intense compared to the same facial expression with a neutral head angle, 87%, $p < .001$, 95% CI [.82 to .91]. Next, I compared Images A and C, and found that the downwards head-tilt anger expression was perceived as conveying significantly less intense anger than the neutral-head anger expression when both featured neutral-head angle eyebrows, 9%, $p < .001$, 95% CI [.06 to .13]. Consistent with my hypothesis, this result suggests that although a downwards head tilt increased the perceived intensity of an anger expression in the first analysis, it did not have this effect when the eyebrows were held constant (see Figure 25).[7]

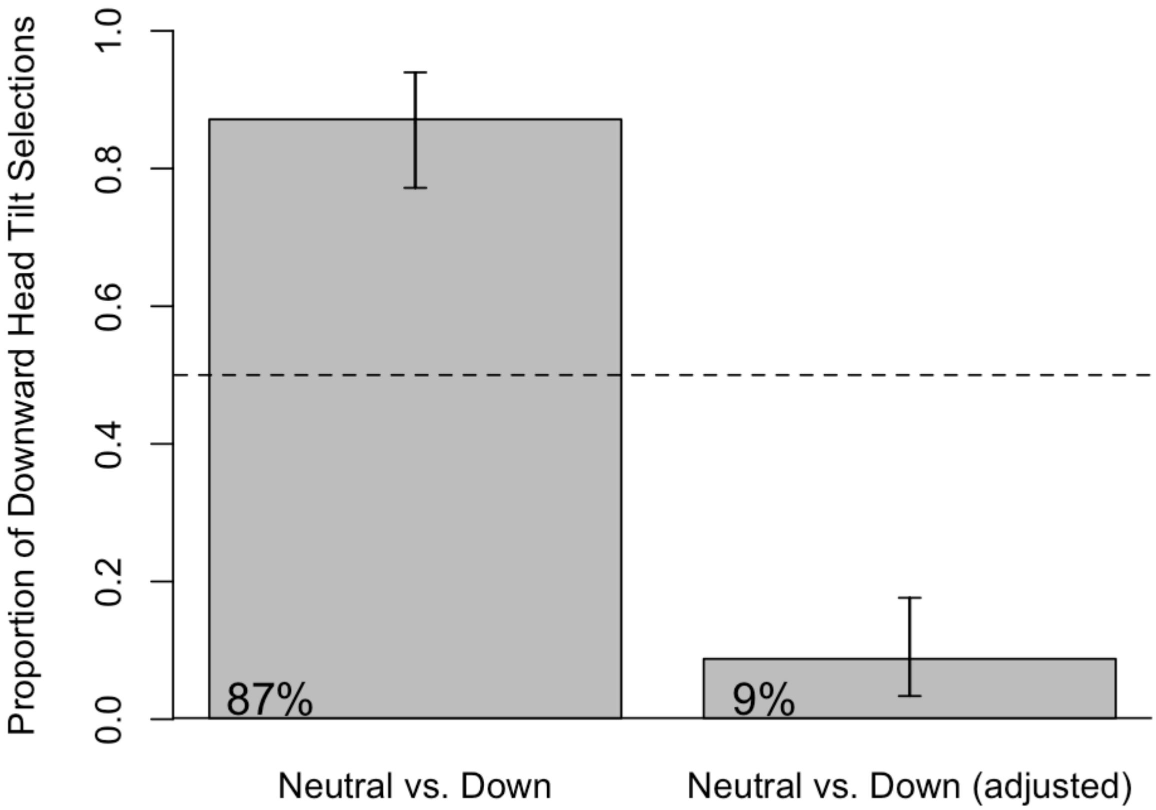


Figure 25. *Proportion of selections indicating that the downward head tilt expression conveys more intense anger compared with a neutral head-angle anger expression when there is no adjustment to the eyebrows (left bar) compared to when the eyebrows were artificially manipulated to appear identical to those in a neutral-head tilt anger expression (right bar). Horizontal dashed line indicates chance level for each comparison (50%).*

Next, I compared Image A with Image D, and found, as hypothesized, that superimposing the downwards head-tilt eyebrows onto a neutral-head angle anger expression caused this expression to convey more intense anger than a neutral-head anger expression with normal eyebrows, 98%, $p < .001$, 95% CI [.96 to .99]. This finding suggests that introducing appearance changes to the eyebrows that are naturally caused by a downwards head tilt – but not any other appearance changes caused by a downwards head tilt – increased the perceived intensity of an anger expression. Importantly, this result also indicates that the weaker intensity of perceived anger in Image C compared with Image A cannot be due to the manipulation of eyebrows in Image C being artificial; here, the image with artificially manipulated eyebrows (Image D) sent the stronger signal of anger.

Exploratory analyses

Although the three comparisons reported above – comparing each image to a neutral-head angle anger expression – were the pre-registered primary tests of my hypotheses, I also examined three additional comparisons, which were pre-registered as exploratory analyses.

First, participants judged the intensity of anger conveyed by a neutral-head-angle anger expression with eyebrows superimposed from a downwards head-tilt anger expression (Image D) with that of a downwards head-tilt anger expression with natural eyebrows (Image B). This comparison tests whether there is any residual effect of a downwards head tilt on the perceived intensity of anger after holding the downwards-head tilt eyebrows constant. Participants identified the neutral head-angle expression as conveying more intense anger, 76%, $p < .001$, 95% CI [.70 to .81], suggesting, somewhat surprisingly, that a downwards head tilt *decreased* perceptions of anger when both images included downward-head tilt eyebrows.

Second, participants judged the intensity of anger conveyed by a downward-head tilt anger expression with eyebrows superimposed from a neutral head-tilt anger expression (Image C) versus that of a downward head-tilt anger expression with natural eyebrows (Image B). This comparison tests whether eliminating the appearance changes to the eyebrows associated with downwards head tilt decreases the perceived intensity of anger when holding all other features of a downwards head tilt constant. Participants identified the downwards head-tilt expression with natural eyebrows as expressing more intense anger, 97%, $p < .001$, 95% CI [.94 to .99], suggesting that eliminating changes to the appearance of the V-shaped eyebrows naturally associated with a downwards head tilt substantially decreased the perceived intensity of anger.

Finally, participants judged the anger conveyed by a downwards head-tilt anger expression with eyebrows from the neutral-head expression superimposed (Image C) with that of a neutral-head angle anger expression with downward-head tilt eyebrows superimposed (Image D). This comparison tests whether participants would judge a face with heightened V-shaped eyebrows as conveying more intense anger than a face with V-shaped eyebrows due to corrugator activity but not heightened by head tilt, even when both are presented with incongruent head-tilt information. It is noteworthy that this comparison directly pits eyebrow V-shape and head-tilt against each other, forcing participants to choose either the face with the stronger downward head tilt or the face with the stronger eyebrow V-shape. Participants very reliably chose the neutral-head angle expression, with the stronger V-shaped eyebrows, as expressing more intense anger, 97%, $p < .001$, 95% CI [.94 to .99].

Discussion

Overall, the results of Study 11 provide strong support for my pre-registered hypotheses: a downwards head tilt increased the perceived intensity of an anger expression, and this effect was due to changes in the appearance of the eyebrows. Specifically, a downwards head tilt increased perceptions of anger formed from an anger expression, but if eyebrows were not permitted to take on a V-shape when the head was tilted down, this head movement no longer increased the perceived intensity of anger. Furthermore, when the eyebrows from a downwards-head tilted anger expression were superimposed onto a neutral-head anger expression, the latter was perceived as expressing more intense anger even when no other appearance changes associated with a downwards head tilt were included. These findings indicate that appearance changes to the eyebrows formed from a downwards head tilt (i.e., the action-unit imposter effect) are necessary and sufficient to increase perceptions of anger formed from a prototypical anger expression.

However, I did observe one unexpected effect. When the eyebrows of a neutral-head anger expression were superimposed onto a downwards-head tilted anger expression, perceptions of anger were *decreased* compared to a natural neutral-head angle anger expression. Interestingly, my exploratory analysis showed a similar effect; when holding the eyebrows constant (regardless of whether neutral eyebrows or downwards-head tilt eyebrows were held constant), an anger expression paired with a downwards head tilt was perceived as conveying less intense anger.

One possible explanation for this pattern is that after controlling for the impact of head tilt on eyebrow appearance, there is a small residual *negative* effect of downwards head tilt on perceived anger. This would be consistent with prior research suggesting that a downwards head tilt functions as a closed and contracted behavior, which can communicate submissiveness, shame, sadness, and therefore reduced anger (Mignault & Chaudhiri, 2003; Witkower & Tracy, 2018; Rule, Adams, Ambady, & Freeman, 2012; but see Study 5 in Chapter 2). Before jumping to conclusions, however, I sought to replicate these findings in Study 12, to make sure all of the uncovered finding are robust. In Study 12, I also aimed to address a central limitation of the current study: its reliance on a single target to convey all expressions, raising the possibility that these results are attributable to something distinctive about that individual.

Study 12

Studies 10 and 11 provide strong support for my pre-registered hypotheses: A downwards head tilt increased the perceived intensity of an anger expression, and this effect was due to changes in the appearance of the eyebrows. In Study 12 I replicated the methodology of Study 11 but included six different targets who varied in gender, to test whether observed effects generalize beyond the single target used in Studies 10 and 11.

Methods and Materials

Participants

Two-hundred, fifty-one adults from Amazon Mechanical Turk participated in the current study; nine of these failed an attention check and were not included in analyses, resulting in a final sample of 242 participants (58% male; age range = 19 - 77, Median = 35 years[8]). This sample exceeded the size necessary to uncover a small effect, based on my power analysis from Study 11, using an alpha of .05, 80% power, a moderate selection proportion (60%), with chance set at 50%.

Stimuli

Six targets (two women, four men) posed an anger expression with their heads at a neutral angle and a second anger expression with their heads tilted down roughly 10-15 degrees. Five of these individuals were recruited for the current study, and the sixth was the same individual used in Study 11, but with altered images re-edited. As was the case in Study 11, all expressions included activation of AU4 and eye gaze directed towards the camera. Targets were asked to remove jewelry and eyewear (if possible), wore a plain white t-shirt, and were photographed while sitting down.

A new graphic artist was recruited and asked to create stimuli similar to those used in Study 11 (see Figure 26). For each target, the artist used the anger expression with the head at a neutral angle (Image A) and the anger expression with the head tilted down (Image B) to create two new images with Adobe Photoshop. Specifically, to create Image C, the artist began with the anger expression in which the target's head was tilted downward (Image B) and replaced the eyebrows in that image with the eyebrows (including furrowing around the glabella) from the image in which the target held his or her head at a neutral head angle (Image A). To create Image D, the artist began with the anger expression in which the target's head was held at a neutral angle (Image A), and replaced the eyebrows in that image with the eyebrows (including furrowing around the glabella) from the image in which the target tilted his or her head down (Image B; see Figure 26).

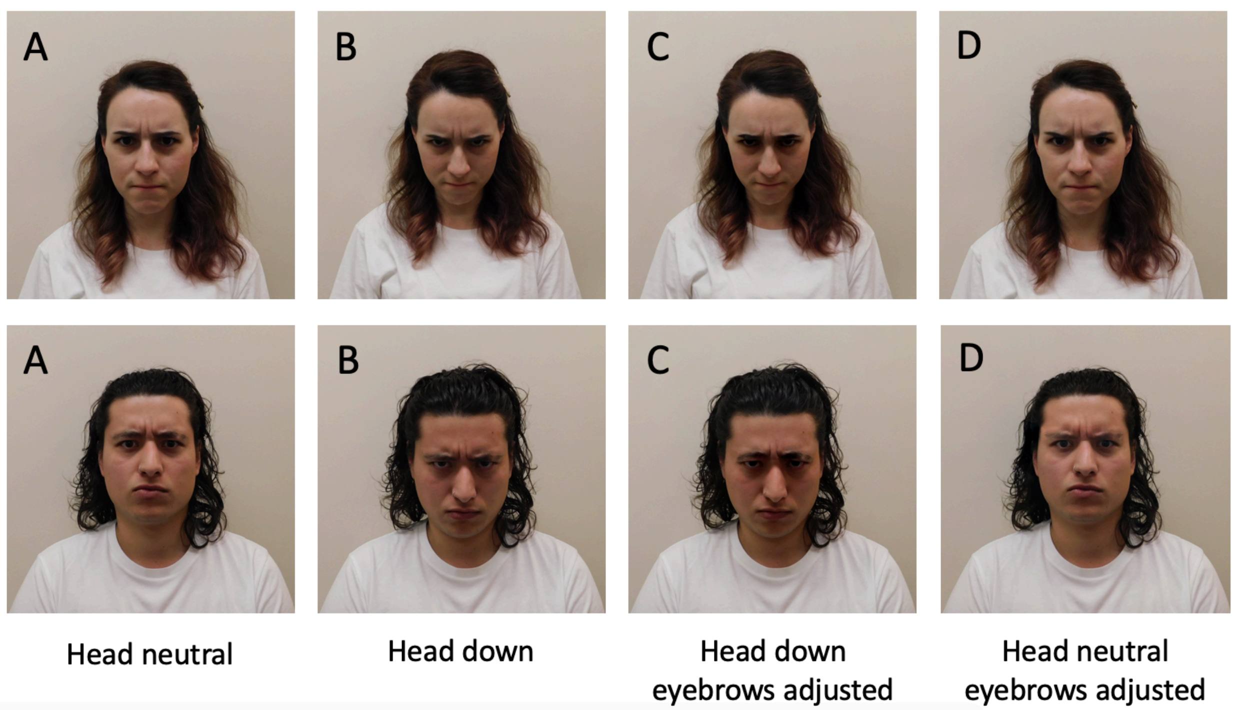


Figure 26. *Stimuli featuring two of the targets included in Study 12. All images feature a prototypical anger facial expression, with the head at a neutral angle (Image A), the head tilted down (Image B), the head tilted down and eyebrows superimposed from Image A (Image C), and the head at a neutral angle and eyebrows superimposed from Image B (Image D).*

More specifically, for each target, the eyebrows and glabella of both anger expressions were selected using the “lasso” tool. A new layer consisting of only the eyebrows and glabella was generated. Using these layers, the eyebrows from the downwards-head-tilt expression were positioned directly on top of the neutral-head-angle expression, whereas the eyebrows from the neutral-head-angle expression were positioned directly on top of the downward-head-tilt expression. The eyebrows from the original photograph layer were removed. Next, the “auto-blend layers” function was applied to the eyebrow and original photograph layers, fusing the two images together. The clone and blur tools were used to adjust discolored areas and to improve blending until the images were satisfactory to the artist. The final image thus consisted of eyebrows that appeared compatible with the face they were superimposed onto, but with the unique shape of each eyebrow and furrowing near the glabella retained from the original image (see Figure 27).

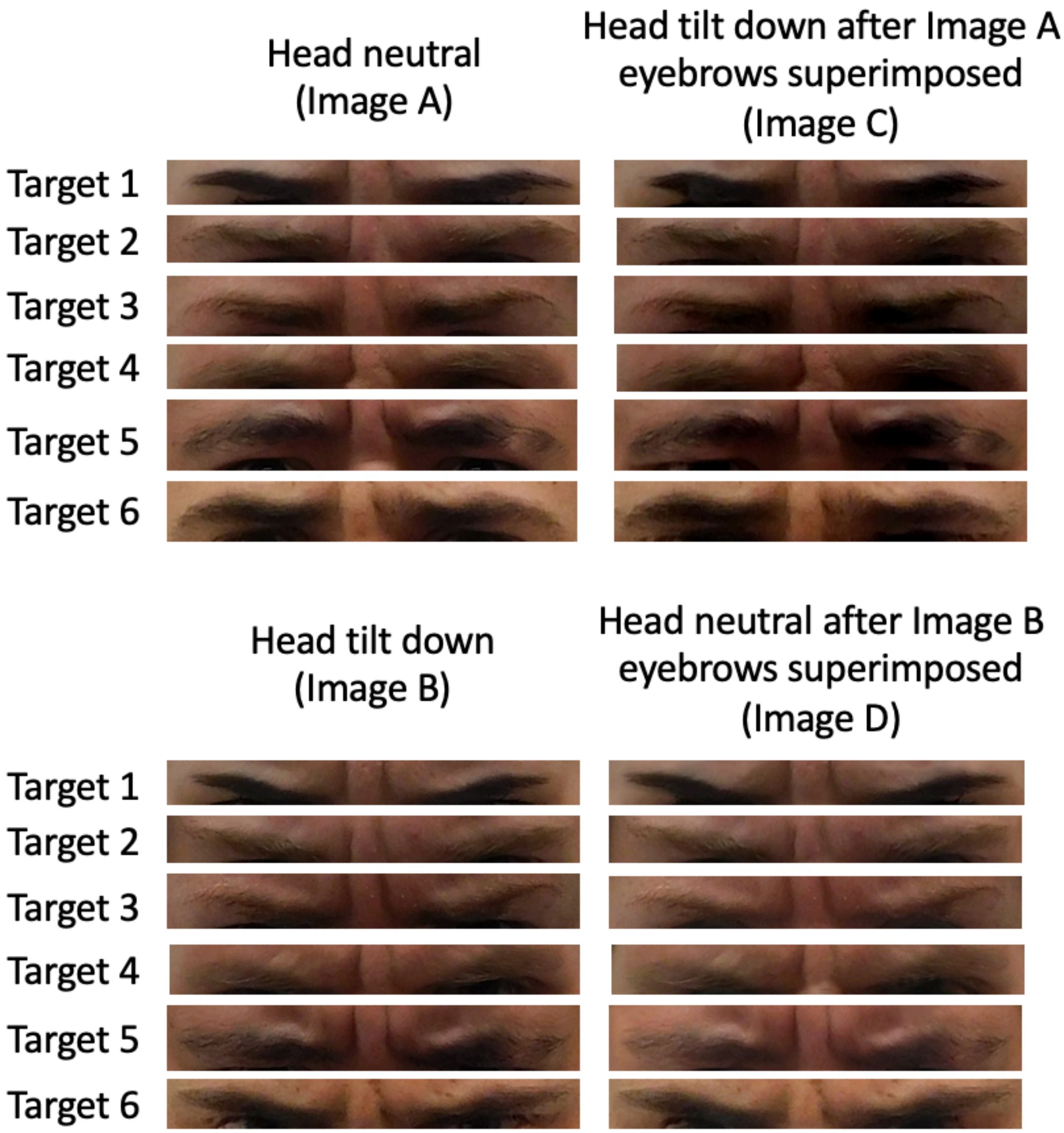


Figure 27. Close-up images of eyebrows from all experimental conditions included in Study 12. Left side: unaltered eyebrows, prior to Photoshop manipulation (i.e., head neutral and head down anger expression; Images A and B, respectively). Right side: eyebrows that were slightly edited after being superimposed onto a downward tilted and neutral head with anger facial expression (Images C and D, respectively). Images were edited by a graphic artist who ensured that the superimposed eyebrows appeared compatible with the face they were superimposed onto but did so without altering the appearance of furrowing around the glabella.

Procedure

Participants completed eighteen trials, in a randomized order, in which they were shown two images side-by-side and asked to select the image in which the target was experiencing more intense anger. For each of the six targets, participants completed the three primary pre-registered comparisons described in Study 11 (Image A versus Image B; Image A versus Image C; Image A versus Image D). The additional exploratory trials included in Study 11 were not included in the current study to reduce participant burden. Participants made all three comparisons for all six targets.

Results

I conducted binomial tests to assess which expression was perceived as a more intense version of anger for each condition, at levels greater than chance (i.e., 50% because in each trial participants selected one of two images). For all analyses, I first aggregated across all targets and perceivers. Analyses with a cross-classified multilevel model did not meaningfully change the pattern reported below.

First, replicating the results of Studies 1 and 2 and supporting my hypotheses, when Image A was compared with Image B, the anger expression with a downwards head tilt was perceived as conveying more intense anger compared to the anger expression with a neutral head angle (86%, $p < .001$, 95% CI [.85 to .88]). This effect did not vary by target gender, $\chi^2(1)$= 0.08, $p = .77$, 95% CI: [-0.05 to .03]; see Figure 28. Second, when comparing Images A and C, the downwards head-tilt anger expression was perceived as conveying slightly more intense anger than the neutral-head anger expression when both featured neutral-head angle eyebrows (58%, $p < .001$, 95% CI [.55 to .61]). This effect varied slightly by target gender, $\chi^2(1)$= 4.43, $p = .04$, 95%CI: [.004 to .11], such that the effect was slightly weaker for male (56%, $p < .001$, 95% CI [.53 to .59]) compared to female (62%, $p < .001$, 95% CI [.57 to .66]) targets. Importantly, however, for both male and female targets, the magnitude of this effect (56% and 62% respectively) was much smaller than the effect emerging from the previous analysis in which the head was tilted down but the eyebrows were not altered (86%), suggesting that the effect of a downwards head tilt on perceptions of anger is largely driven by naturally occurring changes in eyebrow appearance. For results separated by each target, or target gender, see Figure 28 and Table 2).

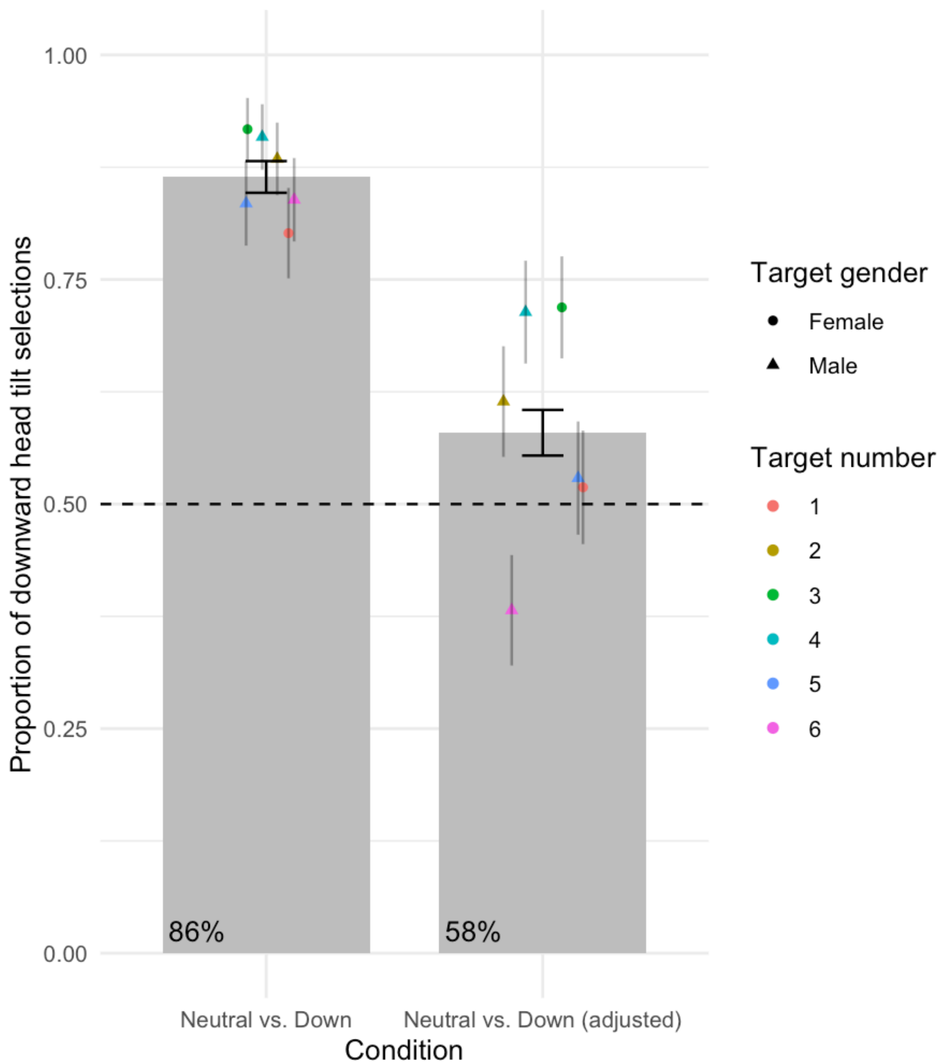


Figure 28. *Proportion of selections indicating that the downward head tilt expression conveys more intense anger compared with a neutral head anger expression when there is no adjustment to the eyebrows (left bar) compared to when the eyebrows were artificially manipulated to appear identical to those in a neutral-head anger expression (right bar). Dots (triangles) represent the proportion of downward head tilt selections for each female (male) target. Horizontal dashed line indicates chance level for each comparison (50%).*

Table 2. Mean downward head tilt selections for each target, Study 12.

	Proportion of downward head tilt selections	***P* value**	***95% CI***
Image A vs Image B			
Across targets	86%	<.001	85% to 88%
By target			
1	*80%*	*< .001*	*75% to 85%*
2	*88%*	*< .001*	*84% to 92%*
3	*92%*	*< .001*	*88% to 95%*
4	*91%*	*< .001*	*87% to 95%*
5	*83%*	*< .001*	*79% to 88%*
6	*84%*	*< .001*	*79% to 89%*
Image A vs Image C			
Across targets	58%	<.001	55% to 61%
By target			
1	*52%*	*.60*	*46% to 58%*
2	*61%*	*<.001*	*55% to 68%*
3	*72%*	*<.001*	*66% to 78%*
4	*71%*	*<.001*	*66% to 77%*
5	*53%*	*.50*	*47% to 59%*
6	*38%*	*<.001*	*32% to 44%*

Note: target-specific effects are in italics. Target 6 was the same target used in Study 11.

Third, further supporting my hypotheses, when comparing Image A with Image D I found that superimposing the downwards head-tilt eyebrows onto a neutral-head angle anger expression caused this expression to convey more intense anger than a neutral-head anger expression with natural eyebrows, (88%, p < .001, 95% CI [.86 to .90]), see Table 3. This effect also varied slightly by target gender, $\chi^2(1)$= 10.98, p < .001, 95%CI: [.03 to .10], such that the effect was slightly stronger for female (92%, p < .001, 95% CI [.89 to .94]) compared to male (86%, p < .001, 95% CI [.84 to .88]) targets. Again, however, for both male and female targets the overall pattern remained the same: superimposing the downwards head-tilt eyebrows onto a neutral-head angle anger expression caused this expression to convey more intense anger. This finding suggests that introducing appearance changes to the eyebrows that are naturally caused by a downwards head tilt – but not any other appearance changes caused by a downwards head tilt – increased the perceived intensity of an anger expression, and this effect was consistent across target gender. Importantly, this result also indicates that the decrease in intensity of perceived anger in Image C compared with Image A cannot be due to the artificial manipulation of eyebrows in Image C; here, the image with artificially manipulated eyebrows (Image D) sent the stronger signal of anger. For results separated by each target, see Table 3).

Table 3. Proportion of selections for Image D (in which targets showed an anger expression with neutral head but eyebrows superimposed from downward-tilted head anger expression), when selecting between Image A and Image D in response to the statement "Please select the image in which the person is experiencing more intense anger"

	Proportion of selections for Image D	**P value**	**95% CI**
Across targets	88%	<.001	86% to 90%
By target			
1	*89%*	*< .001*	*85% to 93%*
2	*82%*	*< .001*	*77% to 87%*
3	*95%*	*< .001*	*92% to 98%*
4	*88%*	*< .001*	*83% to 92%*
5	*85%*	*< .001*	*80% to 89%*
6	*90%*	*< .001*	*86% to 93%*

Note: target-specific effects are in italics. Target 6 was the same target used in Study 11.

Discussion

The results of Study 12 generally replicate those of Study 11 and thus provide further support for my hypotheses: A downwards head tilt increased the perceived intensity of an anger expression, and this effect was due, in part, to changes in the appearance of the eyebrows. Specifically, a downwards head tilt increased perceptions of anger formed from an anger expression, but when the eyebrows were not permitted to take on a V-shape while the head was tilted down, this head movement increased the perceived intensity of anger to a much lesser extent. Furthermore, when the eyebrows from a downwards-head tilted anger expression were superimposed onto a neutral-head anger expression, the latter was perceived as expressing more intense anger even when no other appearance changes associated with a downwards head tilt were included. The results of Study 12 also indicate that the effects uncovered in Study 11 generalize beyond the single target included in that study, and across target gender.

However, I did observe one unexpected effect. When the eyebrows of a neutral-head anger expression were superimposed onto a downwards-head tilted anger expression, perceptions of anger slightly *increased* compared to a neutral-head angle anger expression. This effect is inconsistent with Study 11, in which only a single target was used, raising the possibility that the Study 11 result might be due to something idiosyncratic about the face of that target. Indeed, when I analyzed the data separately for the male target in Study 12 who was also included in Study 11, I uncovered the same (unexpected) pattern as in Study 11: when comparing Images A and C, the downwards head-tilt anger expression was perceived as conveying *less* anger than the neutral-head anger expression when both featured neutral-head angle eyebrows (38%, $p < .001$, 95% CI [.32 to .45]; for separate results for each target, see Table 3). In contrast, for the remaining five targets, comparing Images A and C showed that the downwards head-tilt anger expression was perceived as conveying similar or only slightly more anger than the neutral-head anger expression when both featured neutral-head angle eyebrows. Together, these findings therefore suggest that a downwards head tilt increased perceptions of anger formed from an anger expression, but when the eyebrows of a downward-head-tilt anger expression are edited so as to *not* take on a more intense V-shape, this head movement has a substantially weaker effect, no effect, and for one target, the opposite effect on perceptions of anger.

Study 13

Given the finding from Studies 10, 11, and 12 that a downwards head tilt increases the perceived intensity of anger but decreases the perceived intensity of other emotion expressions, I next sought to test whether individuals spontaneously use this head movement when seeking to express anger, more so than when seeking to express other emotions. Study 13 thus moves beyond examining perceptions of posed expressions to assess how people actually behave when seeking to communicate these emotions, thereby addressing the question of whether head tilt is relevant to the encoding of anger expressions as well as to the decoding of those expressions. More specifically, I examined behaviors shown by targets in the Warsaw Set of Emotional Facial Expression Pictures (WSEFEP; Olszanowski et al., 2015) – a facial expression database featuring images of individuals who engaged in a task that involved reliving emotional experiences before being photographed (Stanislavski, 1936/1988). Targets were trained in how to move their face, but not their head, and in all cases were asked to try to experience the emotion while being photographed. These photos are thus likely to represent the behaviors individuals actually show when feeling a particular emotion, as well as those they think might help communicate the emotion. I predicted that these individuals would spontaneously tilt their heads downward more while posing anger expressions compared to when posing all other emotion expressions, even though they were given no instructions to do so.

Method

The Warsaw Set of Emotional Facial Expression Pictures (WSEFEP)

The Warsaw Set of Emotional Facial Expression Pictures (WSEFEP) is a high-quality, FACS coded, peer-reviewed facial expression database (Olszanowski et al., 2015). It includes images of 30 Polish-speaking individuals displaying seven expressions each (anger, disgust, fear, happiness, sad, surprise, and neutral), for a total of 210 images. Similar to other expression databases, individuals were instructed on how to configure their face for each expression. Unlike other expression databases, however, displayers in the WSEFEP also recalled emotional experiences – along with the physical or physiological sensations associated with those emotion experiences – and engaged in a series of physical activities (e.g., sighing and holding the head in hands for sadness) to help elicit each emotion experience prior to being photographed (Stanislavski, 1936, 1988); the researchers used this technique to increase the authenticity of expressions. As a result, displayers "were inclined not to pose but instead express felt emotions, which were elicited during photo sessions" (p. 2; Olszanowski et al., 2015). In fact, these individuals were first educated on key elements essential for displaying desired expressions, then engaged in training workshops, then practiced at home, and then finally performed the emotion elicitation task in order to evoke each emotion before being photographed. The final photographs can therefore be considered to be relatively authentic expressions, which were selected based on FACS activity and recognizability.

Stimuli and Procedure

All images from the WSEFEP (30 unique targets displaying six emotion expressions and one neutral expression) were prepared for the study by a research assistant blind to the hypotheses. Images were prepared for a team of two nonverbal behavior coders, also blind to hypotheses. They were prepared such that coders were shown two images of a single target individual side-by-side: the target posing a neutral expression was presented on the left, and the target posing an emotion expression (i.e., anger, disgust, fear happy, sad, or surprise) was presented on the right (for a total of 180 trials pairing each emotion expression with the corresponding neutral expression; see Figure 29 for an example). All faces were blurred to obscure facial features and mask the specific expression being displayed. For all stimuli, coders were explicitly told that the image on the left featured a target displaying a neutral head angle,[9] which could be used as a comparison, and that their task was to code the head angle portrayed by the target on the right side.

The two coders then coded the degree of upwards (interrater Cronbach's α = .71) and downwards (interrater Cronbach's α = .88) head tilt of the expressive head in all stimuli, using a rating scale that ranged from 0 (no behavior visible) to 3 (strong behavior apparent). Composite scores for each head tilt direction (i.e., up and down) for each expression were computed by averaging across the two coders' ratings for each trial. Downwards head tilt was the primary dependent variable of interest, but upwards tilt was also coded in order to mask my hypotheses. All trials were presented to coders in a random order.

Figure 29. *Example of stimuli used in Study 13. Nonverbal behavior coders were told that the image on the left was a neutral expression, and were asked to code the degree of head tilt upward and downward of the image on the right.*

Results

I constructed two multilevel models to predict downward head tilt angle and upward head tilt angle from emotion expression (dummy coded, with anger expressions as the reference group), along with random intercepts for targets.[10] Analyses were conducted using the lme4 and lmerTest packages in R (Bates et al., 2015; Kuznetsova, Brockhoff, & Christensen, 2017). The formula for each multilevel model is as follows:

Level 1 model:

$$\textit{Head tilt angle}_{ij} = \beta_{0j} + \beta_{1j}d_{1ij} + \beta_{2j}d_{2ij} + \beta_{3j}d_{3ij} + \beta_{4j}d_{4ij} + \beta_{5j}d_{5ij} + e_{ij}$$

Level 2 model:

$$\beta_{0j} = \gamma_{00} + u_{0j}$$
$$\beta_{1j} = \gamma_{10}$$
$$\beta_{2j} = \gamma_{20}$$
$$\beta_{3j} = \gamma_{30}$$
$$\beta_{4j} = \gamma_{40}$$
$$\beta_{5j} = \gamma_{50}$$

$$e_{1j} \sim N(0, \sigma^2)$$
$$u_{0j} \sim N(0, \tau_{00})$$

First, a multilevel model predicting downwards head tilt from emotion expression, including random intercepts for targets, indicated that targets tilted their heads downward to a significantly greater extent when posing anger expressions compared to all other expressions, including disgust, b = -.40, t(145) = -2.48, p = .01, fear, b = -1.56, t(145) = -9.70, p < .001, happiness, b = -1.46, t(145) = -9.08, p < .001, sadness, b = -1.00, t(145) = -6.19, p < .001, and surprise, b = -.97, t(145) = -5.99, p < .001. The intercept was also significant, b = 1.68, t(111.45) = 12.02, p < .001, suggesting that the downward-head tilt intensity for targets expressing anger was significantly greater than zero. In fact, the intensity of downwards-head-tilt during expressions of anger was above the midpoint of the scale (which ranged from zero to three), and nearly two standard deviations greater than zero (M = 1.68, SD = .92), suggesting that displayers posing anger expressions, following an anger elicitation task, tended to spontaneously tilt their heads downward. Furthermore, these individuals tilted their head downward with a greater intensity when portraying anger compared to when portraying all other emotions (see Figure 30).

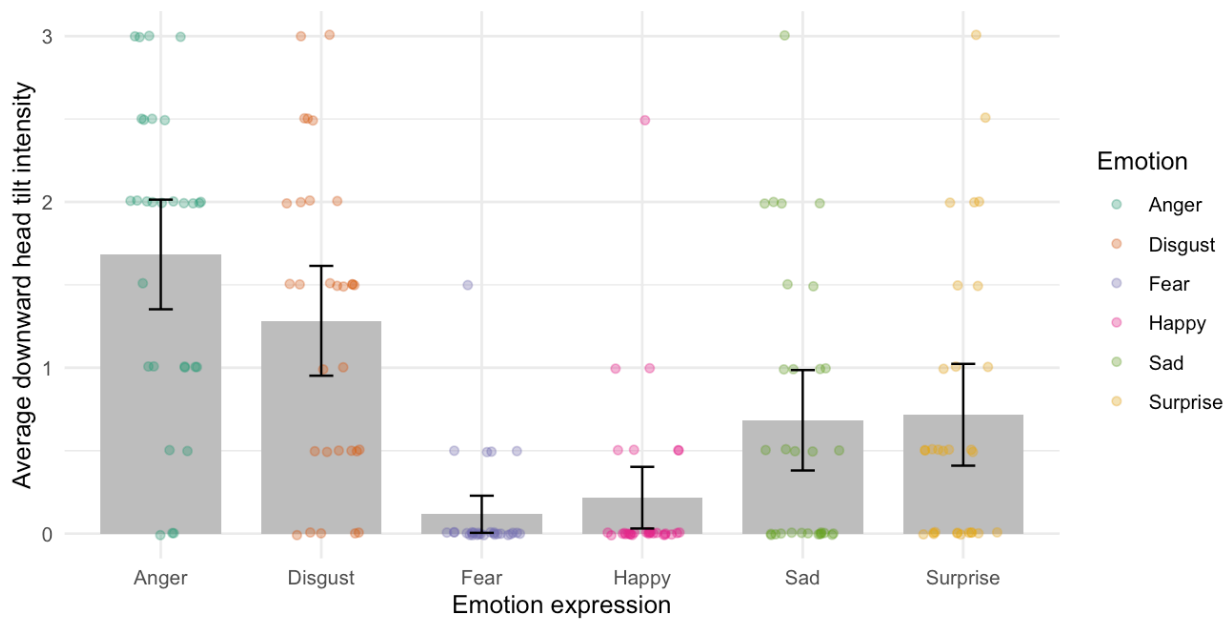


Figure 30. *Average downward head tilt intensity displayed during the posing of each emotion expression. Error bars are 95% CIs. Dots represent the average downward head tilt intensity for each target. Coders rated head movements on a scale ranging from 0 to 3.*

Next, a multilevel model predicting upwards head tilt from emotion expression, including random intercepts for targets, indicated that targets tilted their heads upward significantly less when posing anger expressions compared to expressions of fear, b = .86, t(145) = 6.89, p < .001, and happiness, b = .40, t(145) = 4.03, p < .001. No differences in upwards head tilt intensity emerged between anger expressions and disgust, b = -0.02, t(145) = 0.17, p = .87, sadness, b = 0.11, t(145) = 1.17, p = .24, or surprise expressions, b = 0.05, t(145) = 0.50, p = .62. Furthermore, the intercept was not significant, b = 0.05, t(171.75) = 0.70, p = .49, suggesting that the upward-head tilt intensity for targets expressing anger was not significantly different than zero. These results indicate that targets did not tend to tilt their heads upward when expressing anger, and therefore that their use of downward head tilt during anger expressions was not an artifact of greater head movement in both directions (see Figure 31).

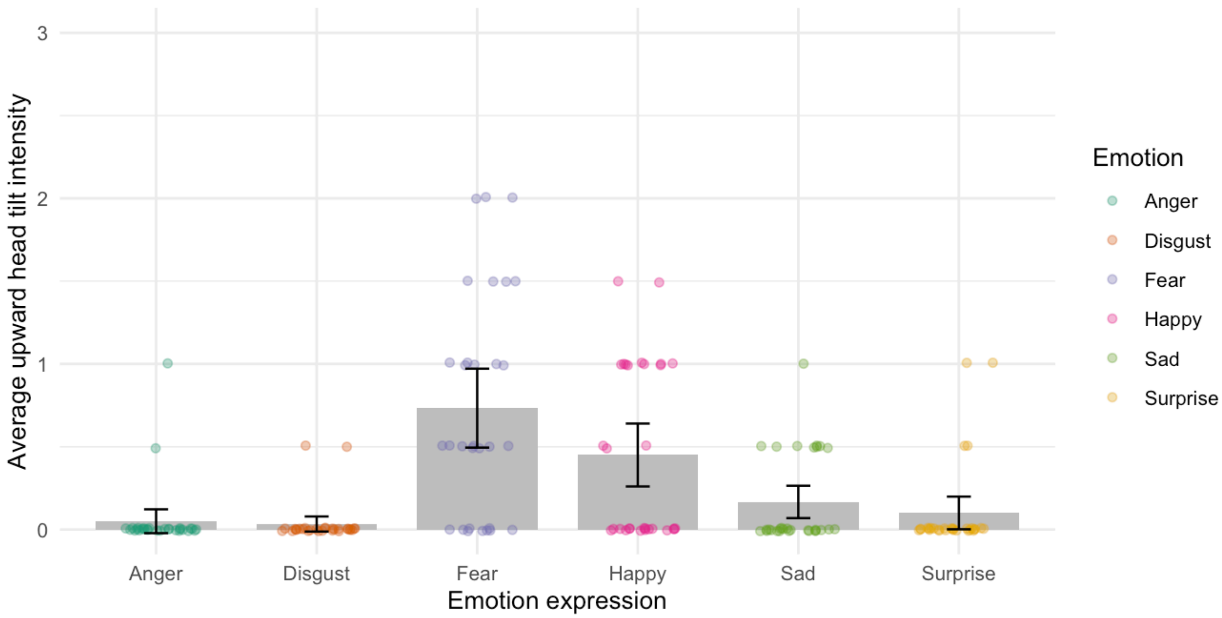


Figure 31. *Average upward head tilt intensity displayed during the posing of each emotion expression. Error bars are 95% CIs. Dots represent the average upwards head tilt intensity for each target. Coders rated head movements on a scale ranging from 0 to 3.*

General Discussion

The current research provides the first evidence that: (a) a downwards head tilt increases the perceived intensity of anger expressions, but decreases the perceived intensity of other emotion expressions that do not include AU4, (b) this effect is attributable to the changing appearance of eyebrows which occurs with a downward head tilt, and (c) individuals spontaneously display a downwards head tilt when showing facial expressions of anger, and this tendency is substantially greater for anger than for expressions of other emotions. Together, these findings suggest that head movement impacts the communication of emotion via the face, and its specific effect depends on the emotion being expressed. Furthermore, these effects occur because head tilt changes the appearance of the face without altering facial muscle activation. One implication of these results, therefore, is that assessing only facial muscle movements when examining facial expressions of emotion may not adequately capture the emotional message that is actually conveyed by that face, unless the head is also considered.

These findings also have important implications for my understanding of anger expressions, in particular. Prototypical anger expressions are often recognized at rates greater than 70% by individuals across cultures (e.g., Olszanowski et al., 2015; Ekman et al., 1987; Tracy, Robins, & Schriber, 2009), yet roughly 85% of participants in my first three studies identified a prototypical anger expression as conveying substantially less anger than a version of the same facial expression that included a downwards head tilt. Future research might therefore consider incorporating a downwards head tilt into anger-expression stimuli to increase the potency of expected effects.

I also found that a downwards head tilt decreased the perceived intensity of all emotion expressions other than anger, but, interestingly, the magnitude of this decrease was smaller for disgust than several other emotions. Similarly, in Study 13, a downwards head tilt was displayed with greater intensity during expressions of anger compared to all other emotion expressions, but individuals posing disgust also tilted their heads down somewhat, and significantly more than when posing all other emotions besides anger. These results suggest that, in addition to mimicking the appearance of AU4, a downwards head tilt might also mimic the appearance of other action units that similarly cause the eyebrows to take on a V-shape– such as AU9, which is displayed during expressions of disgust. Importantly, AU9 includes several appearance changes in addition to V-shaped eyebrows (e.g., pulling the skin alongside the nose upward, raising the infraorbital triangle, widening nostril wings), whereas AU4 more exclusively causes the eyebrows to take on a V-shaped appearance. Downward head tilt does not create these other facial appearance changes, and my findings suggest that this head movement has the largest implications for perceptions of anger, likely for this reason (Witkower & Tracy, 2019a). In fact, when downward head tilt was added to the prototypical disgust expression, it was perceived as conveying *less* intense disgust than when the head was at a neutral angle (Study 10).

It is noteworthy that the current findings advance previous research on the action-unit imposter effect in several ways. First, I show that a downwards head tilt affects the communication of emotions from facial expressions, in addition to trait perceptions of neutral faces as has been found previously (Witkower & Tracy, 2019). Second, I show that a downwards head tilt does not influence recognition for all emotion expressions in a similar way; instead, it increases recognition of anger but decreases recognition of other emotions. Third, I show that these effects are due, at least in part, to the action-unit imposter effect. Fourth, I show that a downwards head tilt is used to express – and not only interpret – anger. The present findings thus demonstrate that the action-unit imposter mechanism has important implications for emotion communication, in addition to the previously established communication of dominance from a neutral (i.e., non-emotional) face.

Another important implication of the present research is that a downwards head tilt might be relevant not only to reliable perceptions of anger (i.e., consensus among viewers, as was demonstrated in Studies 1 through 3) but also to *accurate* perceptions of anger (i.e., valid judgments based on the criterion of an encoder's felt emotional experience, as was demonstrated in Study 13). Indeed, drawing on a Brunswikian lens model framework (Brunswik, 1956; also see Hall, Horgan, Murphy, 2018), the present findings suggest that a downwards head tilt is likely to be both a valid cue of anger and a cue utilized to form perceptions of anger. Future studies might adopt this approach to test whether downwards head tilt mediates accurate interpersonal communication of anger.

One limitation of the current research is that I examined the effect of only one head movement on the perceived intensity of emotion expressions, and only with eye gaze directed forward. Several other head movements are also likely to have implications for emotion perception, including an upward head tilt (Tracy & Robins, 2007; Coulson, 2004; Witkower & Tracy, 2018; Livingstone & Palmer, 2016; Mignault & Chaudhuri, 2003), head yaw (Hess, Adams, & Kleck, 2004), and head roll (Krumhuber, Manstead, & Kappas, 2007; Bee, Franke, & Andre, 2009). In fact, findings from one prior study suggest that head yaw (i.e., horizontal head movement, consistent with the “no” gesture), when paired with an averted eye gaze, can *decrease* recognition of anger and increase recognition of fear, by communicating an avoidance orientation (Hess, Adams, & Kleck, 2004). Given the opposite pattern uncovered in the present work, downward-head tilt appears to have a notably different effect on emotion communication than head yaw, and therefore is likely to capitalize on a different visual mechanism. As demonstrated here, the effect of downwards-head tilt can be explained with the action-unit imposter account, but future research is needed to explore the visual mechanisms responsible for other related effects.

A second limitation of the current research is that only one white American male target was used to express emotions in both Studies 10 and 11. However, this limitation is partially addressed by Study 12, which included six targets who varied in gender. Furthermore, in Study 13, 30 Polish-speaking targets, varying in gender, spontaneously displayed downward head tilting while displaying anger, suggesting that the tendency to use this head movement generalizes at least to some extent. Nonetheless, examining the effect of head tilt on emotion expression recognition across a broader range of targets who vary in ethnicity and age is an important direction for future research.

Another important direction for future research is to examine whether the addition of a downwards head tilt to a prototypical anger expression might increase perceptions of a broader array of antisocial messages, beyond anger. For example, anger is theoretically intertwined with dominance; dominant strategists are likely to engage in outbursts of anger, and capitalize on anger to elicit fear in subordinates (Cheng, Tracy, & Henrich, 2010). Given that facial expressions of anger elicit perceptions of dominance (Hareli, Shomrat, & Hess, 2009; Tiedens, 2001), it is likely that the combination of a downwards-head tilt and an anger facial expression would also increase perceptions of dominance. As noted above, prior work has shown that the combination of a downward head tilt and a neutral facial expression is strongly perceived as conveying dominance; future work is needed to determine whether the images examined here, featuring an anger expression and a downwards-head tilt, elicit even stronger dominance perceptions, or whether the distinct-emotion signal conveyed by the anger facial expression dilutes any other anti-social message.

In conclusion, a downwards head tilt can cause important shifts to the perception of emotions from facial expressions, and this occurs as a result of the action-unit imposter effect. the present findings thus suggest that research on facial expressions of emotion, particularly anger, should pay close attention to the physical foundation of the face: the head.

When smiling faces are not happy faces: How the action unit imposter can turn happiness into schadenfreude.

Happiness is associated with a distinct, prototypical facial expression that is quickly, reliably, and accurately understood by observers across cultures (Snyder, Kaufman, Harrison, & Maruff, 2010; Duchenne, 1862; Hess & Thibault, 2009; Darwin, 1872/1998; Ekman, Sorenson, & Friezen, 1969; Ekman, 1972; Ekman, 1972; Ekman, Sorenson, & Friesen, 1969; Ekman & Friesen, 1971; Izard, 1971; Martin et al., 2020). More specifically, individuals from countries all over the world and of nearly all ages attribute happiness to facial expressions that include activation of the Zygomatic Major (AU 12; "Lip corner puller") and Orbicularis Oculi (AU6; "Cheek raise") facial muscles (Barrera & Maurer, 1981; Cacioppo, Bush, & Tassinary, 1992; Cacioppo, Petty, Losch, & Kim 1986; Ekman, 1992; Ekman et al., 2017; Ekman, Davidson, & Friesen, 1990; Ekman & Friesen, 1982; Frank, Ekman, & Friesen, 1993; Tassinary & Cacioppo, 1992; Kuchuk, Vibbert, & Bornstein, 1986; Tracy & Robins, 2008; Tracy, Robins, & Lagattuta, 2005). However, observers almost never view a prototypical facial expression of happiness in isolation. Instead, happiness facial expressions are almost always seen as they rest upon their physical foundation: the head.

Although prior research suggests that head position can alter how facial expressions expression are perceived (Witkower & Tracy, 2019; Hess, Adams, & Kleck, 2007; Mignault & Chaudhuri, 2003), very little research has explored the consequences of viewing happiness expressions when they appear on a head that is not at a neutral resting position. Here, I argue that head position shifts perceptions formed from happiness facial expressions, and, as a result, the prototypical facial expression of happiness can communicate multiple *different* emotion messages depending on the positioning of the head. Furthermore, I argue that this is the case even when that positioning itself is not visible, such that observers' perceptions are based entirely on information that is apparent in the face. In other words, tilting one's head can alter the appearance of a *face* displaying happiness, such that those same two muscle movements no longer communicate the same message.

How head tilt influences the perception of facial expressions

There is good reason to believe that even small shifts in head tilt (i.e., head pitch rotation) can influence emotion communication. Most notably, a downwards head tilt has been found to increase perceptions of negative emotion facial expressions such as sadness, shame, and anger (Witkower & Tracy, 2019a; Tracy, Robins, & Schriber, 2009; Toscano, Schubert, & Giessner, 2018; Keltner, 1995; Keltner & Buswell, 1997; Livingstone & Palmer, 2016; Mignault & Chaudhuri, 2003; Witkower & Tracy, 2019b). When paired with a neutral facial expression and eye gaze directed forward, a downwards head tilt strongly conveys intimidation and *dominance* – a form of high rank characterized by aggression and threat (Witkower & Tracy, 2019a; Hehman, Leitner, & Gaertner, 2013; Toscano et al., 2018; Witkower, Tracy, Hill, Pun, & Baron, in prep; Witkower et al., 2019a; Torrance; Holzleitner, Lee, DeBruine, & Jones, 2021). Together, these findings suggest that tilting one's head downwards increases perceived negative emotions and antisocial or threatening intentions.

Why head tilt influences the perception of facial expressions

In Chapter 2, I examined the visual mechanism that accounts for these perceptions, and explained many of them on the basis of the *action-unit imposter* effect: tilting the head downward causes one's eyebrows to appear to lower and take on a V-shape, the same appearance changes that occur from activation of the corrugator muscle, or AU4 (Ekman, Friesen, Hager, 2002). Corrugator activation is, in turn, associated with anger and threat across cultures (Ekman et al., 1987; Tracy & Robins, 2008). Tilting the head downward while the face remains neutral (i.e., no corrugator activation) and eye gaze is directed forward therefore leads to anti-social perceptions of threat, intimidation, and dominance by mimicking appearance cues – V-shaped eyebrows – that are associated with particular facial muscle activity (Witkower & Tracy, 2019a). In Chapter 4, I demonstrate that the action-unit imposter effect has implications for facial expressions of emotion. Specifically, in Chapter 4 I demonstrated that a downwards head tilt increases the perceived intensity of anger expressions, and that this effect was attributable to the changing appearance of eyebrows that occurs with the downward tilt; by virtue of increasing the appearance cues associated with corrugator activation, a downwards head tilt caused the prototypically negative and antisocial emotion expression of anger to be perceived as even more intensely angry.

The findings from Chapter 4 make sense in light of the fact that both the anger facial expression and a downwards head tilt communicate negative and antisocial interpersonal messages, so, when combined, a stronger or more intense anti-social message is sent. These findings raise the question, however, of how a downward head tilt might alter the message communicated by a facial expression that does not convey negativity or anti-social intentions. More specifically, how might the interpersonal message communicated by a facial expression of happiness change when combined with a downwards head tilt? One possibility is that the resulting expression will be perceived as a less intense version of happiness, and communicate an antisocial rather than prosocial message.

Downward Head tilt + Happiness = Schadenfreude?

Given that a downwards head tilt creates the appearance of V-shaped eyebrows, which mimics the appearance of corrugator muscle activation – a movement associated with the communication of threat and anger across cultures – I propose that the combination of a prototypical happiness expression and a downwards head tilt will communicate a blend of anger and happiness: *schadenfreude* – an emotion defined as the experience of pleasure of misfortune of another (Lange & Boecker, 2019; Lange, Weidman, & Crusius, 2018; Smith, Turner, Garonzik, Leach, Urch-Druskat, & Weston, 1996; Van de Ven, Hoogland, Smith, van Dijk, Brugelmans, & Zeelenberg, 2014). If this hypothesis is supported, it would have an important implication beyond shedding light on how an additional distinct emotion is communicated nonverbally; it would suggest that relying on facial muscle activity alone, to characterize a message communicated from the face, is insufficient. Even the most prosocial facial expression of warmth, friendliness, and trustworthiness – the smile – can send a contradictory and antisocial message when presented with a downwards head tilt. At a broader level, then, to characterize the social messages communicated from the face, researchers cannot rely exclusively on facial muscle movements, but must instead consider the face and the head in unison. Furthermore, for researchers to understand *why* a happiness expression communicates something other than happiness, or, more broadly, why any prototypical expression might communicate multiple different messages during different occasions, they need to consider the head and the face simultaneously.

Prior research on a schadenfreude expression

Previous researchers theorized that a distinct expression of schadenfreude would be likely to combine facial cues involved in both anger and happiness expressions (Hofmann, Ruch, &

Platt, 2012; Cikara & Fiske, 2012; Boecker, Likowski, Pauli, & Weyers, 2014; Du, Tao, & Martinez, 2014). On the basis of this reasoning, studies examined whether schadenfreude is communicated by an expression that includes facial features typical of happiness, such as AU 12 (Zygomatic Major – lip corner puller, creating the prototypical "smile" appearance) and AU6 (Orbicularis Oculi- cheek raiser, creating crow-feet wrinkles), along with facial features typical of anger, such as AU4.

In contrast to these expectations, however, individuals experiencing schadenfreude have been found to show decreased, rather than increased, activation of AU4 (Cikara & Fiske, 2012; Boecker et al., 2014). Furthermore, AU4 is generally *unlikely* to be activated when AU12 is also activated (Cikara & Fiske, 2012; Boecker et al., 2014). These findings suggest that, to effectively communicate schadenfreude, an expression would need to convey happiness and threat yet not simultaneously feature both smiling (AU12) and corrugator activation (AU4). In light of the action-unit imposter effect, tilting one's head downward might provide a solution; the head movement would produce the appearance of corrugator activity without actual activation, and there is no evidence to suggest that smiling cannot or does not co-occur with any particular head movement. The resulting combination of behaviors -- Duchenne smile (AU 6+12), with a downwards head tilt and eye gaze directed towards the perceiver – might therefore provide an ideal combination of threat and happiness to convey schadenfreude.

The Current Research

In three pre-registered studies; osf.io/evmnc; osf.io/udqw9; osf.io/xyc9v), I tested whether tilting one's head downward systematically changes the perceptions formed from a prototypical happiness expression. I hypothesize that when such an expression is paired with a downwards head tilt, it will *not* be perceived as happiness, but instead as schadenfreude.

Together, these studies are the first to test whether head movement can shift the emotion message communicated by a prototypical happiness expression, such that the resulting expression communicates a categorically different emotion.

Study 14

In Study 14 I tested whether a happiness expression with a downwards tilted head is less likely to be judged as conveying happiness and more likely to be judged as conveying schadenfreude, when compared to a neutral head angle happiness expression. These hypotheses were pre-registered at osf.io/xyc9v along with the method, sample size, and analysis plan.[11]

Method

Participants

One-hundred, sixty adults from Amazon Mechanical Turk participated in the current study; 14 of these failed an attention check and were not included in analyses, resulting in a final sample of 146 participants (46% male; age range = 19 - 66, Median = 33 years). This sample exceeded the size necessary to uncover a moderate sized effect (i.e., 65% agreement) based on my pre-registered power analysis using an alpha of .05 and 80% power, and chance set at 50%.

Materials and Procedure

Participants were shown two images side-by-side of the same facial expression: a prototypical happiness display (AUs 6+7+12).[12] In one of the two images, the head was positioned at a neutral angle, and in the other the head was tilted down roughly 10-15 degrees. In both images, the target directed their eye gaze towards the camera (AUs 54+63; see Figure 32). In all images, expressions were posed (and later FACS-coded) by the same male target in his mid 20s, wearing a white tee-shirt.

Participants viewed these two side-by-side images twice; in one trial, they were asked to indicate which expression conveys more intense "happiness," and in the other they were asked to indicate which expression conveys more intense "pleasure at the misfortune of another". The latter item was used to measure schadenfreude, consistent with past research examining recognition of this emotion in American samples (Cikara & Fiske, 2012; Boecker, Likowski, Pauli, & Weyers, 2014). These two trials were intermixed among other trials examining recognition of several other emotions, reported in Witkower and Tracy (2020).

Figure 32. *Emotion expressions, with the head at a neutral angle (left) and tilted downward (right), Study 14.*

Results and Discussion

Two binomial tests were conducted to assess whether participants selected the downward-head tilted version of the happiness expression as less intense happiness, and more intense schadenfreude, at levels greater than chance (i.e., 50%). To account for multiple comparisons, highly conservative 99.99% CIs were constructed around all estimates. As hypothesized, when the head was tilted downward the expression was selected as less intense happiness, 15%, $p < .001$, 99.99%CI [.06 to .30], and more intense schadenfreude, 86%, $p < .001$, 99.99%CI [.72 to .95]; see Figure 33. These results support my pre-registered hypothesis that a happiness expression with a downwards tilted head is less likely to be judged as conveying happiness but more likely to be judged as conveying schadenfreude, compared to a neutral head angle happiness expression.

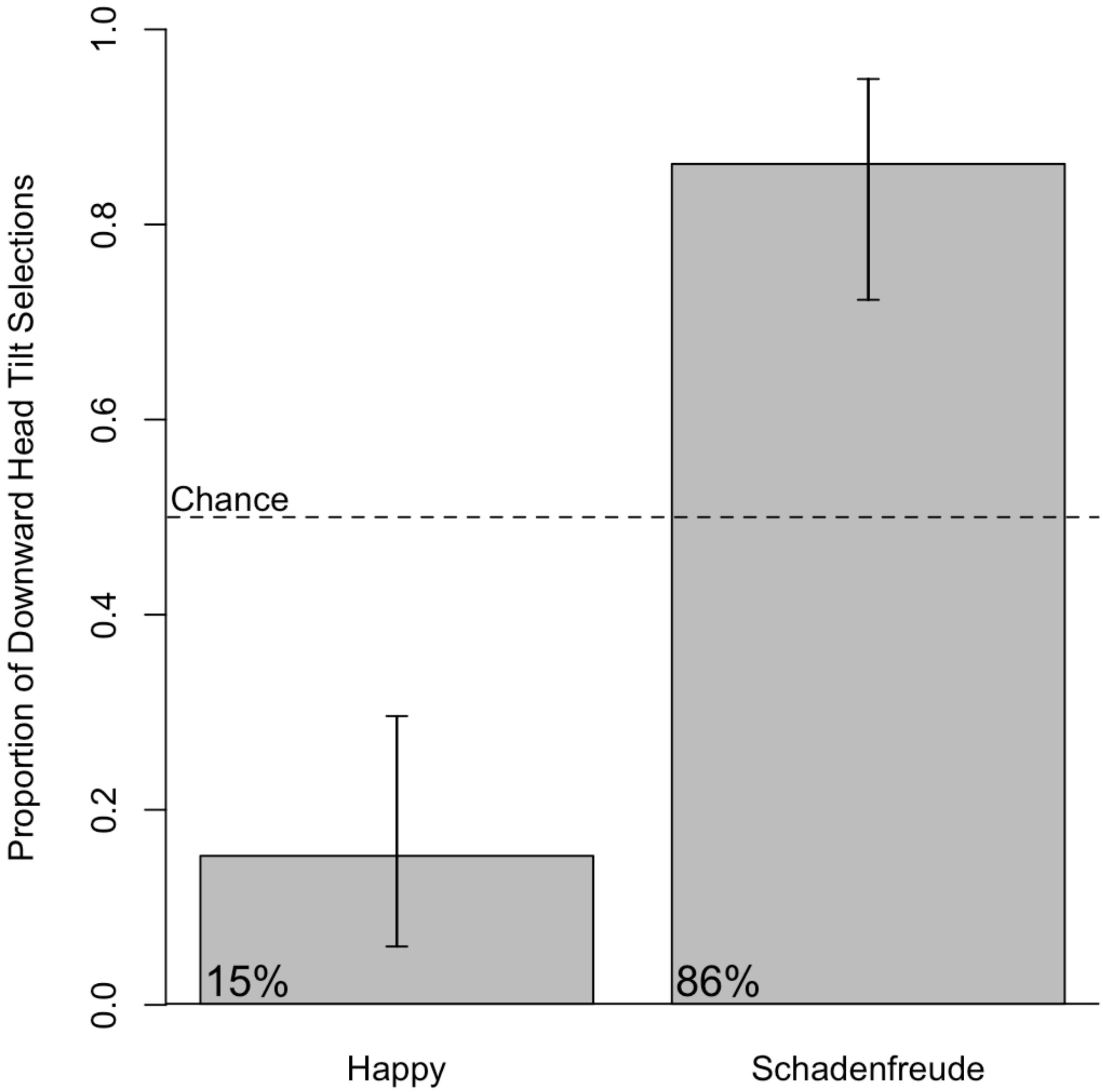


Figure 33. *Proportion of downward head tilt selections in response happiness prompt (left) and the schadenfreude prompt (right). Error bars illustrate 99.99% CIs. The horizontal dashed line indicates chance level (50%).*

Study 15

One implication of the results of Study 14 is that the emotion of schadenfreude might have a distinct, recognizable nonverbal expression, which involves a combination of facial and head movements. In Studies 15 and 16 I test this possibility by examining whether this expression is reliably recognized as schadenfreude when participants are not forced to choose which of two expressions best conveys that emotion. In Study 15, participants rated the extent to which a happiness expression and the proposed schadenfreude expression, along with a variety of other expressions, elicit perceptions of happiness and schadenfreude. In a second task, participants selected the emotion label that they believed best characterized the proposed schadenfreude expression.

I hypothesized that the proposed schadenfreude expression would be rated as conveying greater schadenfreude when compared to other emotion expressions, and also as conveying less happiness than the same expression with a neutral head angle (replicating Study 14). I also hypothesized and pre-registered that recognition of the schadenfreude expression would be significantly greater than chance (8% based on the number of response options provided), and significantly greater than 25%, a secondary more stringent performance criterion sometimes used in recognition studies (e.g., Haidt & Keltner, 1999), to address the fact that actual chance responding is based entirely on the number of options provided and thus can be a fairly uninformative benchmark.

In Study 15 I also explored several explanations for the finding of Study 14. Although it is possible that the combination of a downwards head tilt and facial expression of happiness is a distinct signal of schadenfreude, it is also possible that this combination of behaviors communicates a variety of antisocial yet positively valenced emotions, in addition to (or instead of) schadenfreude. In particular, I tested whether this expression might convey hubristic pride. This is a form of pride characterized by feelings of arrogance and egotism, and associated with dominance (Tracy & Robins, 2007a; Tracy & Robins, 2004; Cheng, Tracy, & Henrich, 2010; Witkower, Mercadante, & Tracy, 2021;

Mercadante, Witkower, & Tracy, 2021; Witkower, Mercadante, & Tracy, 2021; Tracy, Mercadante, & Witkower, 2020). Hubristic pride and schadenfreude are both antisocial but positively valenced emotions which are associated with the acquisition of social rank (Cheng, Tracy, & Henrich, 2010; Weidman & Tracy, 2019; Lange & Boecker, 2019). I therefore tested whether a display featuring the combination of a downwards head tilt and facial movements associated with happiness is a distinct signal of schadenfreude, or reliably conveys hubristic pride as well.

I also included a nonverbal expression of pride as an additional control expression. This expression includes a prototypical happiness expression with the head tilted *upwards* (Tracy & Robins, 2004); including it therefore allows us to test whether a happiness expression paired with any head tilt – up or down – will communicate schadenfreude, or whether a smile communicates schadenfreude only when paired with a downwards head tilt. Given that the action unit imposter mechanism is specific to a downwards (and not upwards) head tilt (Witkower & Tracy, 2019), I predicted that perceptions of schadenfreude would be highest for my proposed schadenfreude expression. However, given that the pride expression communicates hubristic pride (Tracy & Robins, 2007)– an emotion that, like schadenfreude, is positively valenced yet antisocial – I also expected the combination of an upwards head tilt and happiness expression to increase perceptions of schadenfreude, but to a lesser extent than that of a downwards head tilt and happiness expression. I pre-registered all of these hypotheses, along with the method, sample size, and analysis plan at osf.io/udqw9.

Method

Participants

Eighty-six adults were recruited from Amazon Mechanical Turk; 13 of these failed an attention check and were not included in analyses, resulting in a final sample of 73 participants (59% male; age range = 18 - 61, Median = 32 years). Based on my pre-registered power analysis, this sample exceeded the number necessary to uncover a moderately sized effect (f = .20) in a one-way repeated measures

ANOVA, with an alpha of .005 (anticipating a large correction for pairwise comparisons), a typical correlation among repeated measures (r = .40), no correction for violating sphericity, and 80% power. This also exceeded the sample size necessary to uncover an effect in a binomial test (discussed below).

Procedure

In this two-part study, participants were first shown seven facial expressions in a randomized order. For each expression, participants indicated the extent to which the person displaying each expression was feeling “angry”, “disgusted”, “happy”, “fearful”, “sad”, “contemptuous”, and “pleasure at the misfortune of another” (to assess schadenfreude). These items were selected to capture a broad range of emotions, and to serve as fillers to mask the critical DV: “pleasure at the misfortune of another” (schadenfreude). I also measured recognition of authentic and hubristic pride using items from the Authentic and Hubristic Pride scales (Tracy & Robins, 2007) that have been found to load highly onto the respective authentic and hubristic pride factors: “confident and accomplished” (to assess authentic pride), and “arrogant and conceited” (to assess hubristic pride). Participants responded to each prompt using a 7-point rating scale ranging from 1 (“Not at all”) to 7 (“Extremely”).

In a second part of the study, participants were shown the target schadenfreude image in isolation and asked “which of the following descriptions best characterizes this person's expression?”. They selected from all nine emotion labels used in the first part of the study, along with three additional options: “none of these options”, “I do not know what this person is feeling”, and “other: __________”, for a total of 12 response options. This item was used as a secondary assessment of schadenfredue recognition.

Stimuli

Six expressions were posed and FACS coded by the first author, who is certified in the Facial Action Coding System: the proposed schadenfreude expression (AUs 6+12+54+63), happiness (AUs 6+12), intense happiness with the lips parted (AUs 6+12+25), pride (AUs 6+12+53+64), anger (AUs

4+5+7+17+24), a neutral expression (AU 0), and a control expression that combined the upper face of an anger expression with the lower face of a happiness expression (AUs 4+6+7+12; see Figure 34). This last expression has been theorized to communicate schadenfreude in past research (Cikara & Fiske, 2012; Boecker, Likowski, Pauli, & Weyers, 2014), but no prior studies have tested whether it does, in fact, lead to perceptions of schadenfreude.

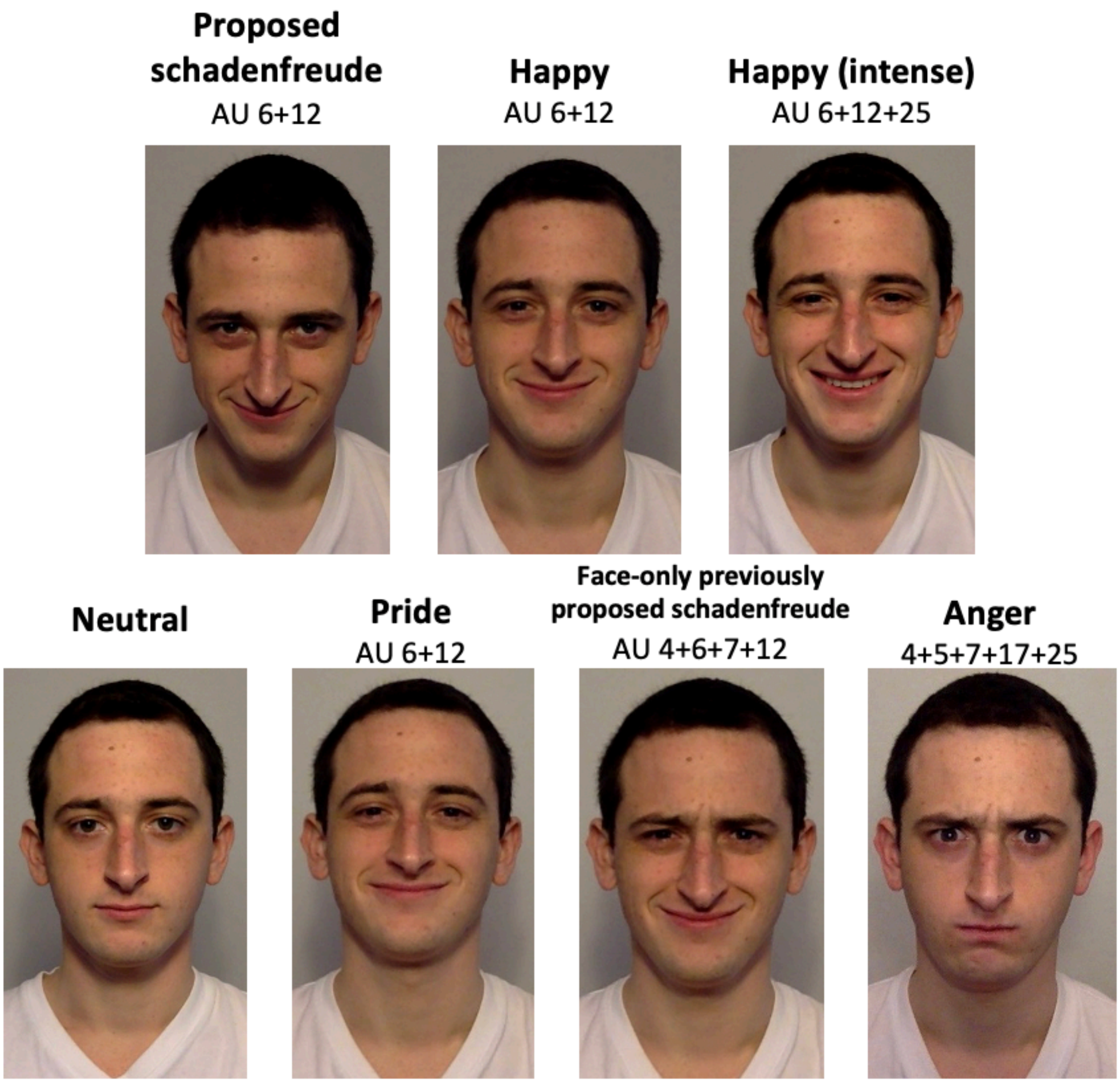


Figure 34. *Expressions used in Study 15. Numbers indicate action units from the Facial Action Coding System, without head movement codes.*

Results

Mean differences in emotion perception

First, to test whether my proposed schadenfreude expression led to the highest perceptions of schadenfreude, I conducted a one-way repeated measures ANOVA on perceptions of schadenfreude based on responses using the ratings scale. A significant effect emerged, $F(6,432) = 33.43$, $p < .001$, $\eta_p^2 = .32$, indicating that the proposed schadenfreude expression was perceived as conveying greater schadenfreude compared to all other expressions, all *p*s < .001, all *d*s > .56 (see Figure 35), including happiness ($p < .001$, $d = .98$), and pride ($p < .001$, $d = .56$), both of which consist of identical facial muscle movements.[13]

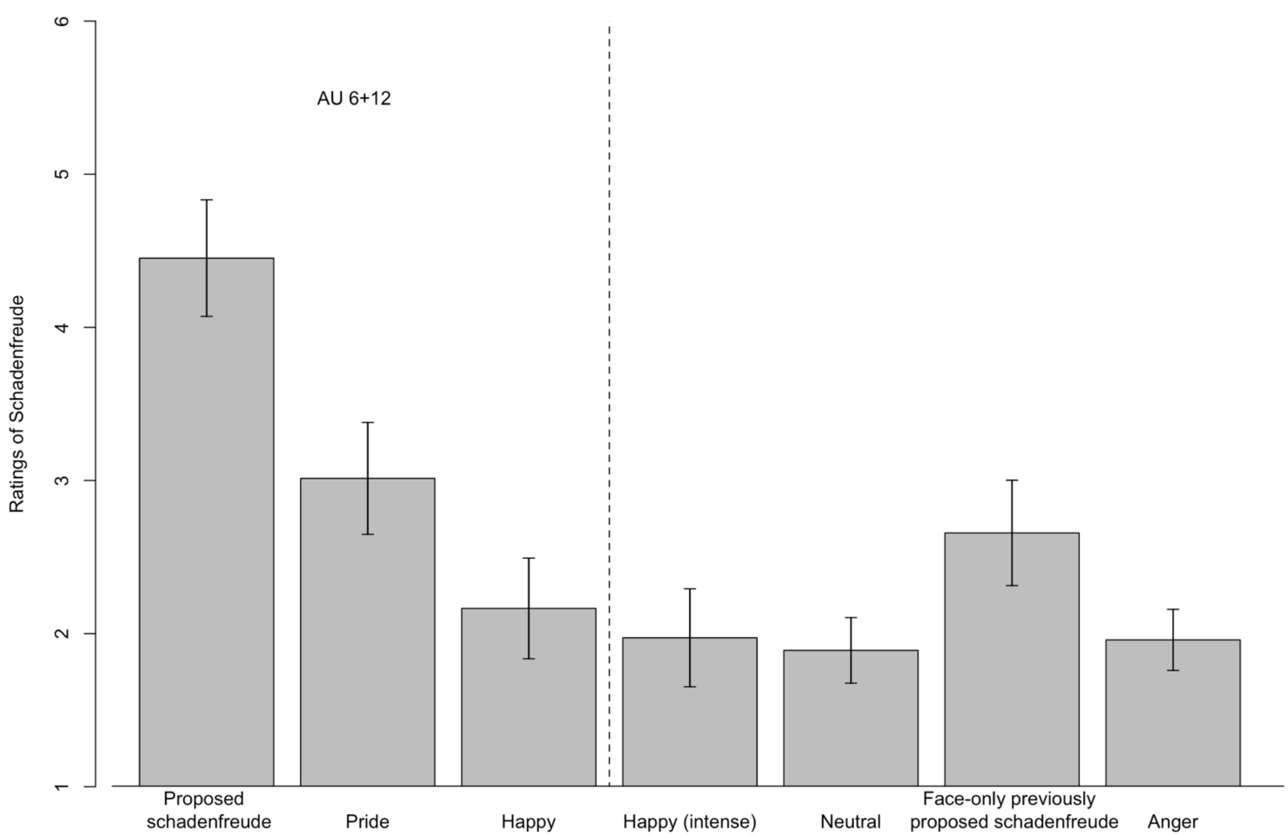


Figure 35. *Ratings of schadenfreude for each expression, Study 15. Error bars indicate 95% CIs.*

Next, I conducted a one-way repeated measures ANOVA on perceptions of happiness to test whether the prototypical happiness expression led to the highest perceptions of happiness compared to all other expressions. A significant effect emerged, $F(6,432) = 110.47$, $p < .001$, $\eta_p^2 = .61$, indicating that the intense happiness expression was perceived as happier than the moderate happiness expression, $p = .05$, $d = .37$, and all other expressions, *p*s < .001, *d*s > .59. Importantly, the schadenfreude expression was judged as conveying less happiness compared to the both happiness expressions, *p*s < .001, *d*s > .72.

To examine whether the proposed schadenfreude expression might communicate antisocial positive emotion, in general, rather than schadenfreude, in particular, I next conducted an exploratory analysis testing whether this expression increased perceptions of hubristic pride compared to all other expressions. A one-way repeated measures ANOVA on perceptions of hubristic pride yielded a significant effect, $F(6,432) = 23.75$, $p < .001$, $\eta_p^2 = .25$. The proposed schadenfreude expression was perceived as conveying more hubristic pride than both happiness expressions (*d*s > 1.00, *p*s < .001), but was not significantly different from the pride expression, $p = .054$, $d = .32$, with an effect trending in the opposite direction than expected, such that the proposed schadenfreude expression was identified as marginally higher in hubristic pride than the pride expression ($M_{\text{Pride expression}} = 3.71$, $M_{\text{Proposed Schadenfreude}} = 4.37$). These results suggest that the schadenfreude expression communicates hubristic pride – another antisocial positive emotion – in addition to schadenfreude. Notably, mean ratings of schadenfreude from the schadenfreude expression were no different than mean ratings of hubristic pride from this same expression, $p > .99$, $d = .03$.

Forced Choice Emotion Identification

To test whether participants were most likely to identify the proposed schadenfreude expression as "pleasure at the misfortune of another" when asked to choose only one label, I conducted a binomial test on responses to the second measure of schadenfreude recognition. The schadenfreude label was selected 32% of the time – a rate significantly greater than chance (8%, given the 12 response options), $p < .001$, 99.99% CI [.21 to .43]. As a more stringent test, I next repeated this analysis with chance set at 25%. Schadenfreude was not identified as “pleasure at the misfortune of another” significantly greater than chance using this conservative threshold, $p = .22$, 95% CI [.21 to .43].

Next, I conducted a binomial test to examine whether participants identified the proposed schadenfreude expression as happiness significantly more frequently than chance. The happiness label was selected 14% of the time – a rate not significantly above chance levels, $p = .46$, 95%CI [.07 to .24], and significantly lower than the rate at which the schadenfreude label was selected ($p < .001$).

Finally, I used the same test to compare rates at which participants identified the proposed schadenfreude expression as schadenfreude versus as hubristic pride. The hubristic pride label was selected 29% of the time, a rate significantly greater than chance, $p < .001$, 95%CI [.19 to .41], and not significantly different than the rate that the schadenfreude label was selected, $p = .62$, 95%CI [.19 to .41].

Discussion

Study 15 tested whether a display featuring the combination of a downwards head tilt and a prototypical happiness facial expression is reliably recognized as schadenfreude. Results were somewhat mixed. Consistent with my hypotheses, the schadenfreude expression was perceived as conveying greater schadenfreude than was any other expression examined, including two happiness expressions with no head tilt, an anger expression, a pride expression, and another expression previously proposed to represent schadenfreude with facial muscle activity only. My proposed schadenfreude expression was also perceived as conveying less happiness than both a moderate and intense happiness expression, despite sharing the same facial muscle movements.

However, the proposed schadenfreude expression also communicated hubristic pride at levels comparable to the pride expression and comparable to the level at which it communicated schadenfreude. Furthermore, although the proposed schadenfreude expression was identified as schadenfreude at a rate significantly greater than chance, it was identified as hubristic pride at a similar rate. Both rates were fairly low (i.e., not significantly different than my pre-registered comparison rate of 25%). Together, these results clearly indicate that a facial expression of happiness (i.e., AUs 6 + 7 + 12) does not reliably communicate happiness when the head is tilted downward; instead, this combination communicates an antisocial positive emotion, such as schadenfreude or hubristic pride. However, the present results leave open questions about whether this expression communicates positively valenced but anti-social emotions broadly speaking, or the two specific anti-social and positively valenced emotions examined here in particular. In addition, the low recognition rates that emerged suggest that this expression is unlikely to be a strong, readily interpretable signal of schadenfreude.

One possible explanation for these mixed findings is that Americans are not familiar with the concept of schadenfreude, and therefore failed to discriminate between hubristic pride and schadenfreude. Indeed, the word "schadenfreude" is of German origin, and although it directly translates to "pleasure at the misfortune of another," cultural nuances and the concept itself might not fully translate to English-speaking populations. This lack of clarity could have led to low recognition of a real schadenfreude expression among individuals who do not hold a clear understanding of the concept. In Study 16, I addressed this possibility by examining whether German participants more reliably recognize the proposed schadenfreude expression.

Study 16

Method

Participants

One-hundred students were recruited from the University of Cologne in Germany (36% male; age range = 18 - 53); all spoke German fluently and 91% indicated that German was their first language. Based on my pre-registered power analysis, this sample exceeded that necessary to uncover a moderate sized effect in a one-way repeated measures ANOVA, with on an alpha of .005 (anticipating a large correction for pairwise comparisons), a highly conservative correlation among repeated measures (r = .00), a correction for violating sphericity (.50), and 80% power. This sample size also exceeds the size necessary to detect a significant effect in a binomial test with a conservative chance threshold set to 25%, alpha at .05, and 80% power.

Procedure

The procedure and stimuli were identical to Study 15, except that the current study was conducted entirely in German. All items were translated into German by the third author (JL), and back-translated by a German-speaking research assistant blind to the hypotheses.[14] The critical item, "this person is experiencing pleasure at the misfortune of another," was translated to "Die Person ist schadenfroh", which back-translated to, "The person is experiencing Schadenfreude (joy at another person's misfortune)."

Results

Mean differences in emotion perception

To test whether my proposed schadenfreude expression led to stronger perceptions of schadenfreude compared to the other expressions included, I conducted a one-way repeated measures ANOVA on schadenfreude ratings. A significant effect emerged, $F(6, 594) = 64.33$, $p < .001$, $\eta_p^2 = .39$, indicating that the proposed schadenfreude expression was judged as higher in schadenfreude than all other expressions, *p*s < .001, *d*s > .71, with the exception of the pride expression, which was judged as less strongly expressing schadenfreude, but, after a conservative Bonferroni correction, not significantly so, $p = .76$, $d = .21$; without Bonferroni correction $p = .04$, $d = .21$; see Figure 36. The pride expression was also judged as conveying greater schadenfreude than both happiness expressions (*ps* < .001, *d* > .70). The face-only schadenfreude expression proposed in past research (Cikara &

Fiske, 2012) was also judged as conveying greater schadenfreude than both happiness expressions (*p*s < .004, *d*s > .42), but significantly less than my proposed schadenfreude expression ($p < .001$, $d = .71$).

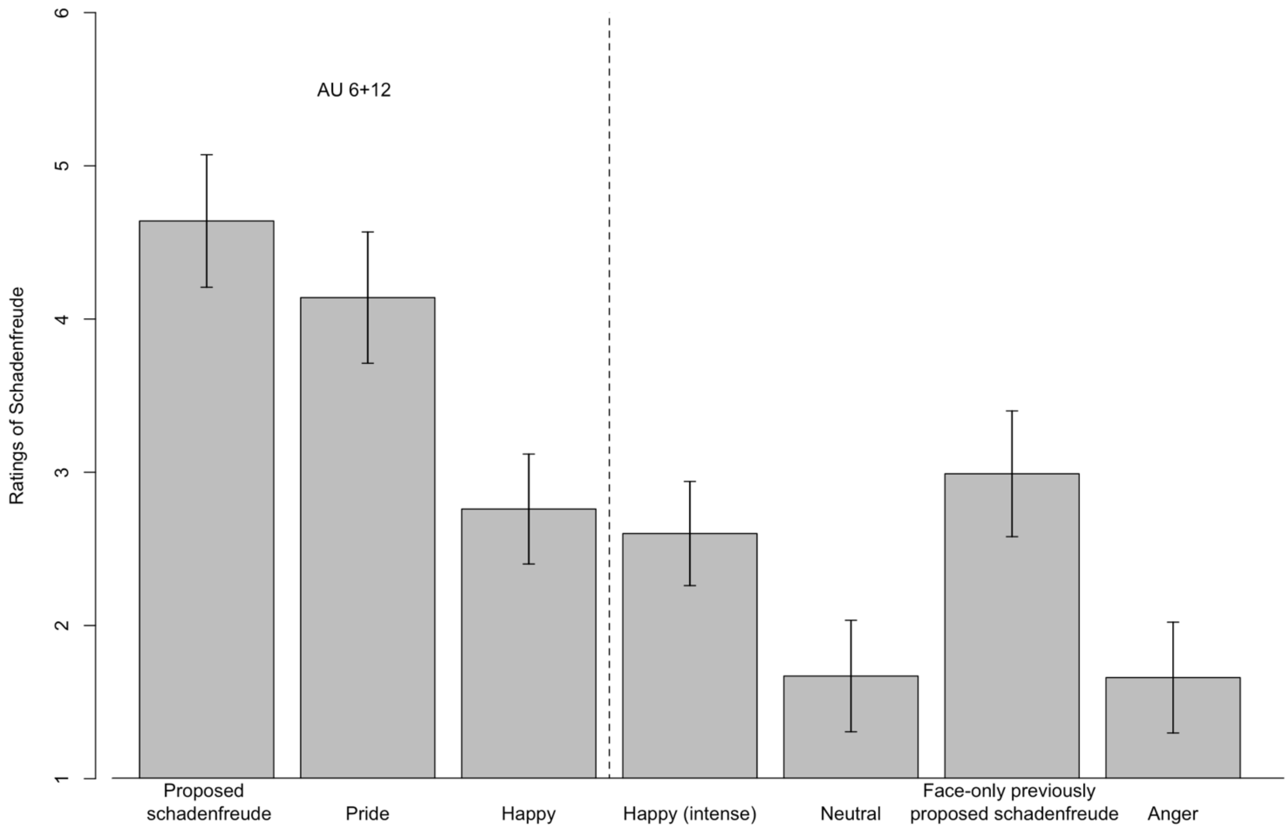


Figure 36. *Germans' perceptions of schadenfreude from each expression shown in Study 16. Error bars indicate 95% CIs.*

Next, I conducted a one-way repeated measures ANOVA on perceptions of happiness, to test whether the prototypical happiness expression led to the highest perceptions of happiness compared to all other expressions, including the proposed schadenfreude expression. A significant effect emerged, $F(6, 594) = 207.93$, $p < .001$, $\eta_p^2 = .68$, indicating that the intense happiness expression was perceived as happier than the moderate happiness expression, $p = .01$, $d = .36$, as well as each other expression, *p*s < .001, *d*s > .77, including the proposed schadenfreude expression, which featured the same facial muscle movements. The proposed schadenfreude expression was also perceived as conveying less happiness than the moderate happiness expression, *ps* < .001, *ds* > .78.

As an exploratory follow-up analysis, I next tested whether the proposed schadenfreude expression increased perceptions of hubristic pride compared to other expressions. A one-way repeated measures ANOVA on perceptions of hubristic pride yielded a significant effect, $F(6,594) = 60.55$, $p < .001$, $\eta_p^2 = .38$. Replicating finding from Study 15, the proposed schadenfreude expression was judged as conveying more hubristic pride than both happiness expressions (*p*s < .001, *d*s >.83), but was not significantly different from the pride expression, $p > .99$, $d = .06$.

Forced choice emotion identification

Using the binomial test, I next tested whether participants reliably identified the schadenfreude expression as "pleasure at the misfortune of another". The schadenfreude identification rate was 37%, which was significantly greater than chance (8%, given that the 12 response options), $p < .001$, 95% CI [.28 to .47], but also not particularly high. Using the more stringent chance criterion of 25%, schadenfreude recognition was still statistically significant, $p = .007$, 95% CI [.28 to .47].

To more directly address the question of whether a downward head tilt converts a happy facial expression into schadenfreude, I conducted a follow-up binomial test comparing frequencies of identifying this expression as schadenfreude versus happiness. The happiness label was selected 9% of the time – a rate not significantly different from chance, $p = .63$, 95%CI [.04 to .16], and significantly less than the rate at which the schadenfreude label was selected, $p < .001$.

I next conducted an exploratory binomial test comparing rates of schadenfreude and hubristic pride identification, for the proposed expression, to probe the finding that emerged from the continuous ratings and from Study 15. The hubristic pride label was selected for the proposed schadenfreude expression 7% of the time, a rate not significantly different than chance, $p = .85$, 95%CI [.03 to .14], and significantly lower than the rate at which the schadenfreude label was selected, $p < .001$. This result suggests that although this expression conveys both hubristic pride and schadenfreude to some extent in Germany, when German participants are forced to choose one response or the other, they are considerably and significantly more likely to choose schadenfreude.

A final binomial test was conducted to determine whether Germans identified the proposed expression as schadenfreude more frequently than did the Americans in Study 15. Results indicate no significant difference between the two recognition rates (37% vs. 32%), $p = .29$, 95% CI [.28 to .47].

Discussion

Results from Study 16 largely replicate those of Study 15 with a German sample. Once again, the schadenfreude expression was perceived as conveying greater schadenfreude than all comparison expressions except pride, but in this case that last comparison trended in the predicted direction. The proposed schadenfreude expression was also again perceived as conveying less happiness than both intense and moderate happiness expressions, despite sharing the same facial muscle movements as the moderate happiness expression.

Turning to my forced choice response item, participants selected the schadenfreude label for the proposed schadenfreude expression at rates significantly greater than chance and more frequently than they chose any other emotion label – including happiness and pride. In contrast to the findings of Study 15, Germans did not frequently identify the proposed schadenfreude expression as hubristic pride. Taken together, results from this study suggest that the proposed expression is perceived as communicating schadenfreude more than it is perceived as any other emotion in Germany, but identification rates are not high enough to indicate that the expression is a robust and highly reliable signal of schadenfreude even among a population familiar with the concept.

General Discussion

The current set of studies are the first to demonstrate that head movement can shift the emotional message communicated by a prototypical happiness facial expression, such that it is no longer perceived as expressing happiness but instead as an antisocial positively valenced emotion, such as schadenfreude or hubristic pride. More specifically, in Study 14 I found that my proposed schadenfreude expression was identified as conveying less intense happiness but more intense schadenfreude when compared with the same expression with the head at a neutral angle (i.e., the prototypical happiness facial expression). In Study 15, I found that the proposed schadenfreude expression was judged as conveying greater schadenfreude than six other theoretically relevant expressions. A similar pattern emerged in Study 16, among a sample of German participants, though perceptions of schadenfreude formed from the proposed schadenfreude expression were not significantly greater than perceptions of schadenfreude formed from the pride expression, after a conservative Bonferroni correction to account for multiple comparisons (with Bonferroni correction, $p = .76$, $d = .21$; without Bonferroni correction, $p = .04$, $d = .21$).

In both Studies 15 and 16, participants also identified the proposed schadenfreude expression as conveying hubristic pride, in addition to schadenfreude. Both hubristic pride and schadenfreude are antisocial positively valenced emotions, suggesting that participants may have perceived the proposed schadenfreude expression as communicating a more general sense of antisocial intent along with a pleasurable subjective feeling experience, rather than schadenfreude specifically. Nonetheless, when forced to choose a single emotion label, German (but not American) participants selected the schadenfreude label significantly more frequently than any other.

The extent to which the proposed expression was perceived as conveying hubristic pride versus schadenfreude varied across the US and Germany. When responding in a forced-choice manner, German participants were more likely to identify it as schadenfreude than hubristic pride, even though their continuous ratings suggested a tendency to judge the expression as conveying both emotions to a similar extent. These results suggest that, in Germany, the proposed expression communicates an antisocial positive emotion that is ultimately more suggestive of schadenfreude than hubristic pride. In contrast, American participants judged the proposed expression as equally high in both emotions when making both continuous and forced-choice ratings. This difference between samples is consistent with the notion that schadenfreude might be more distinctive in Germany than the USA.

In general, identification rates for the proposed schadenfreude expression were somewhat low in both Studies 15 and 16 (32% and 37%, respectively). These low rates may partly be due to my inclusion of a larger number of alternative response options than is typical of emotion recognition studies, which frequently ask participants to choose from 3 to 5 emotion labels when identifying any given expression, compared to 12 in the present study. Nonetheless, if the proposed expression was a strong signal of schadenfreude, I would expect higher rates than those observed here, even with the greater number of response options; the present results thus suggest either that schadenfreude is not entirely distinct from other antisocial positive emotions, or that my proposed expression is not robustly associated with the emotion. Future research is needed to test whether schadenfreude has a distinct nonverbal expression that is highly recognizable.

Despite the ambiguity regarding individuals' perceptions of the proposed expression, the present findings have important implications for research on happiness. Although prototypical facial expressions of happiness have been shown to communicate warmth, trustworthiness, and prosocial motives (Mehu, Grammer, & Dunbar, 2007; Wang, Mao, Li, & Liu, 2017; Hess, Beaupré, & Cheung, 2002), the present research demonstrates that this same facial expression can also communication the opposite set of messages. In fact, for a prototypical happy face to communicate happiness, it *must* be presented with a neutral head angle. Relying on activation of the Zygomatic Major muscle and/or Orbicularis Occuli muscle without taking into account head position to characterize expressions of happiness can be misguided.

One important limitation of the present research is my reliance on a single target. Future studies are therefore needed to examine recognition of the proposed schadenfreude expression when shown by other targets, ideally varying in gender and ethnicity. I would expect the present results to generalize across such target characteristics, given that a downwards head tilt with neutral face is reliably judged as conveying threat and power across a variety of targets (Witkower & Tracy, 2019), and smiling faces are reliably judged as conveying happiness across a wide range of targets (e.g., Olszanowski et al., 2015).

In conclusion, head pitch rotation can cause important shifts in the way that happiness facial expressions are perceived. A downwards head tilt changed perceptions of a prototypical happy face, such that the resulting expression communicated antisocial positive emotions like schadenfreude and hubristic pride, but no longer happiness.

Overview and implications of the Action Unit Imposter

The current dissertation provides the first evidence that the action unit imposter mechanism guides perceptions formed from expressionless (i.e., neutral) and emotionally expressive (e.g., displaying anger, happiness) faces across cultures. First, in Chapter 2, I (a) provided evidence that a downwards head tilt increases perceptions of dominance from a neutral face, (b) demonstrated that this effect occurs by changing the apparent V-shape of the eyebrows, in particular, and (c) ruled out the possibility that any of the other previously proposed mechanisms are viable alternative explanations. Next, in Chapter 3, I showed that the AU imposter mechanism is likely to be a universal feature of human visual cognition by demonstrating that it guides social perceptions among the Mayangna – members of a highly divergent, unindustrialized, small-scale traditional society in Nicaragua. Finally, in Chapters 4 and 5 I demonstrated that the AU imposter mechanism systematically influences social perceptions of emotionally expressive faces alongside neutral ones – including perceptions formed from facial expressions of anger (Chapter 4), and happiness (Chapter 5). Together, this research demonstrates that the action unit imposter is likely to be a universal feature of human communication that guides social perceptions when humans move their faces and heads.

Previously proposed mechanisms

The current set of studies also provides evidence that systematically rules out all mechanisms previously proposed to explain why head movement guides social perceptions. The strongest evidence in support of the AU imposter mechanism that also simultaneously rules out plausible alternative mechanisms emerges from Study 5. There, participants identified a neutral face with downwards head tilt as dominant when viewing only the eyes and eyebrows – that is, with the neck, jaw, mouth, head, and body not visible. Importantly, they did *not* identify this same face with a downwards head tilt as dominant when the eyes and eyebrows were occluded but those other parts of the face fully visible. If changes to the appearance of the neck, jaw, mouth, head, body, or any other part of the face besides the eyes and eyebrows accounted for the effect of a downwards head tilt on perceptions of dominance, the opposite pattern would have emerged. This design therefore pitted the AU imposter mechanism against all other previously proposed mechanisms, and results suggest that the AU imposter is most likely to be guiding perceptions of dominance from a downwards head tilt.

Strong evidence for this account also comes from Studies 6,7, 11, and 12, in which participants identified a downwards head tilt as dominant (or angry; Studies 11 and 12), but did *not* do so when the eyebrows were visually altered, such that they were manipulated to not change in appearance from how they look with a neutral head angle. Stated differently, the effect of a downwards head tilt on perceptions of dominance (and anger) no longer emerged after methodologically controlling for appearance changes to the eyebrows that naturally occur while tilting the head down, despite the presence of appearance changes to all other parts of the face – such as the neck, jaw, mouth, head, body. In all of the above-mentioned studies (Studies 5, 6, 7, 11, and 12), I directly manipulated the appearance or visibility of the eyebrows and consequently demonstrated that apparent eyebrow V-shape is the causal mechanism that is necessary and sufficient for a downwards head tilt to increase perceptions of dominance and anger. This pattern of results is consistent with the action unit imposter mechanism, but not with any other previously proposed visual mechanism.

Notably, in Studies 7, 8, 9, and 12, changes to the appearance of the eyebrows accounted for only part of the effect of a downwards head tilt on perceptions of dominance, whereas in Studies 5, 6, and 11 these changes accounted for the entire effect. Given these somewhat mixed results, it is possible that several of the previously proposed mechanisms, either separately or in combination, have some small additional effect on perceptions of dominance. However, any such effects emerged only inconsistently across the present research, and were much smaller than that of the AU imposter mechanism.

Theoretical implications of the AU imposter

Neutral-face perception.

The AU imposter effect has important implications for social impressions formed from neutral faces. First and foremost, the presence and magnitude of this effect tells us that individuals whose faces are devoid of muscle activation can still send salient social messages by changing the angle of their head. As a result, although individuals might not expect or intend to convey social information when they exhibit a neutral facial expression, their face can still contain an abundance of such information that has the potential to guide an observer's thoughts, feelings, and behavioral responses toward them. Individuals should therefore consider the role of the body and head, alongside the face, when employing or regulating nonverbal behavior during social communication. This implication is likewise important for researchers who study the downstream subjective or objective consequences, or accuracy, of impressions formed from "neutral" faces; such scholars must ensure that any effects they observe are not an artifact of differences in head positioning. Researchers can address this issue by methodologically or statistically controlling for the head position of targets, or demonstrating that a reported effect is robust when analyzing a subsample of targets showing a neutral head angle.

The present research also highlights an important facial mechanism for guiding perceptions formed from neutral faces – V-shaped eyebrows – along with a procedure to measure eyebrow V-shape (see Study 8). Given that neutral faces vary in eyebrow V-shape, individual differences in this facial feature might explain individual differences in perceptions of trait dominance or anger formed from neutral faces Furthermore, V-shaped eyebrows could influence a variety of perceptions in addition to dominance; perceptions of trustworthiness– the core dimension that observers use to guide social perceptions (Oosterhof & Todorov, 2008; Jones et al., 2021) – are most strongly affected by a face's structural resemblance to emotion expressions of anger, when compared to other proposed mechanisms (Jaeger & Jones, 2020; Said, Sebe, & Todorov, 2009). Eyebrow V-shape, which captures appearance cues associated with corrugator muscle activation, is likely to contribute to a face's structural resemblance to expressions of anger, and therefore likely to guide perceptions of anger, dominance, and also trustworthiness. Future research should assess eyebrow V-shape of neutral faces as a specific visual mechanism responsible for guiding trait perceptions of dominance, threat, and trustworthiness.

Emotion perception, automated coding, and emotion measurement.

A rather large body of research has focused on how and when specific facial muscle actions are relevant for emotion communication (e.g., Ekman & Friesen, 1974; Ekman & Keltner, 1997; Matsumoto, Keltner, Shiota, O'Sullivan, & Frank, 2008; Fridlund, Ekman, & Oster, 1987). Yet research on facial expressions typically excludes the critical role of head movement. For example, head angle and eye position codes are often secondary to face coding, and, in some cases, entirely optional (e.g., many questions on the FACS Final Test to become certified as a FACS coder do not require it). As demonstrated here, head position has a large influence on social and emotion perception, and should be considered alongside facial muscle action coding. In particular, in Studies 10-12, I found that a downward head tilt intensifies the communication of anger from a prototypical anger expression, in Study 13 that individuals use a downwards head tilt to express anger, and in Studies 14 and 15 that a downwards head tilt can categorically change the message communicated from a happiness expression. Based on these findings, future research on emotion communication must treat head position as a substantive variable that contributes to recognition and perception by measuring head position alongside facial muscle activation; failing to do so will lead to insufficient or inaccurate characterizations of the message communicated from the face.

Consistent with the tendency for existing research to undervalue the role of head position in emotion communication, several services are available to measure emotion expressed in the face with automated emotion coding, and they almost always fail to identify head position as a substantive feature of emotion communication, instead relying exclusively on facial muscle activations. However, one of the first steps these programs use to detect facial muscle activation is to determine the location and orientation of the head, in order to specify the precise location of facial landmarks in an image. Head position therefore can be (and often is) identified from photographs during automated emotion coding, but is not treated as a substantive variable relevant to emotion gleaned from the face. Instead, expressionless faces with the head tilted down are typically identified as “neutral”. As an illustration, the neutral head angle and downward head tilt stimuli used in Study 2 were passed through Microsoft Azure and Google Vision AI to assess the emotion present in the face. Both platforms identified all images as “neutral”, or “very unlikely” to be expressing a threatening emotion such as anger (see Figure 37). In fact, the two expressions – a neutral face presented on a neutral head angle and a neutral face with downwards head tilt, clearly identified as dominant and at least somewhat angry by human perceivers– are classified as similarly “neutral” by the automated systems. As the present research demonstrates, an expression with the head tilted down – even if the face is devoid of activation – is far from neutral, and should not be classified this way.

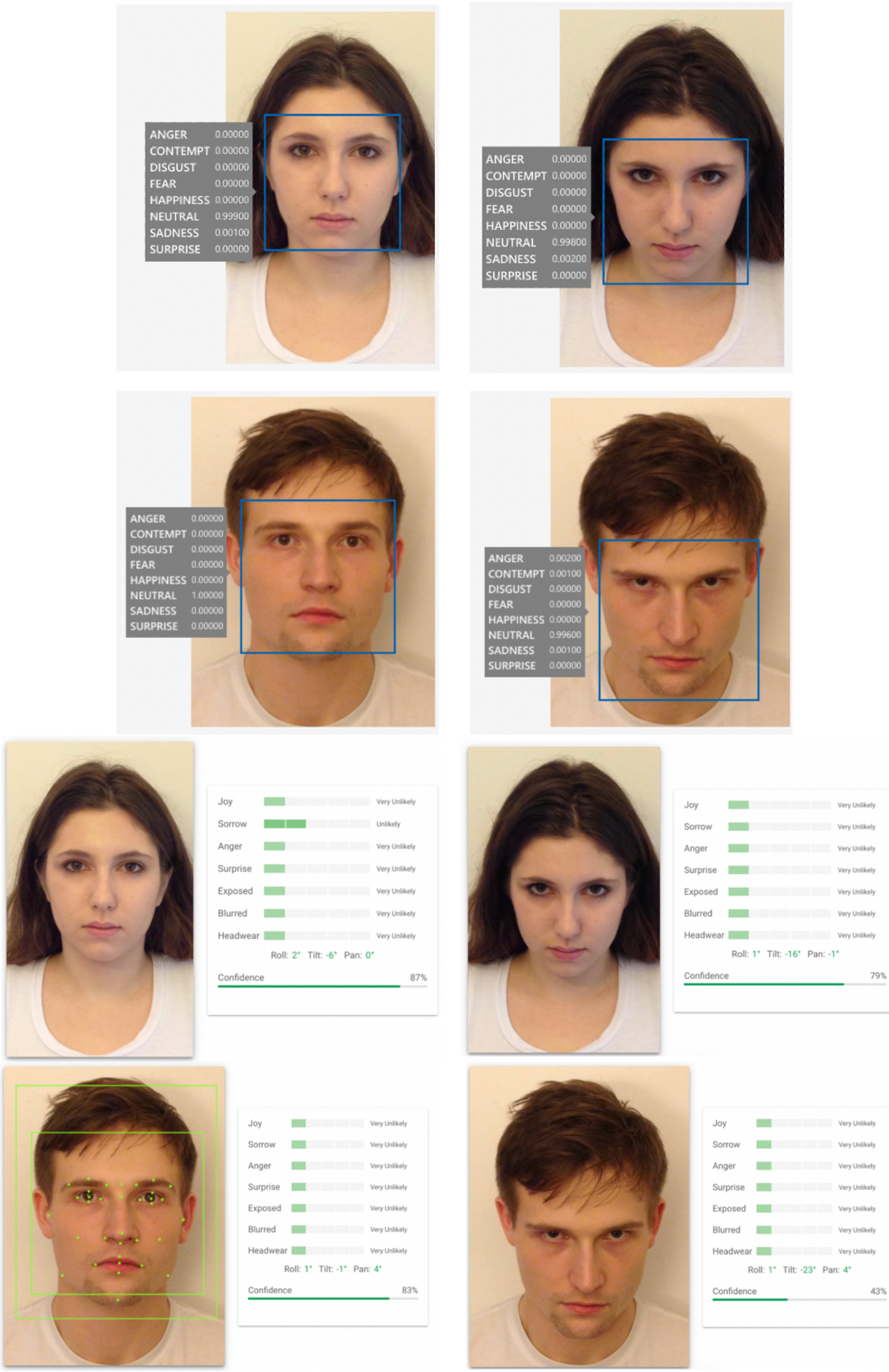


Figure 37. Automated emotion coding of neutral head angle and downward head tilt stimuli used in Study 2, using Microsoft Azure (top) and Google vision AI (bottom).

The role of angularity in threat communication

Although the present research makes clear that a downwards head tilt increases perceptions of dominance by mimicking appearance cues associated with AU4, it is currently unknown *why* these appearance cues lead to this social perception—that is, why AU4 is a threat signal. Given that AU4 (and head tilt down) creates the appearance of angularity from the eyebrows, one possibility is that humans possess a broader cognitive association between angularity, in general, and threat. From an evolutionary standpoint, this association would likely be adaptive, as there are very few angular or sharp objects that are not dangerous or a threat to humans' safety; sharp rocks, pointy sticks, teeth, and horns, all of which have been in humans' local environments throughout their evolutionary history, have the potential to inflict harm or be dangerous. Our species might therefore have an evolved association between angularity and threat that functions to help us avoid threats to my physiological safety, or identify features of the environment that can be used as tools or weapons.

An association between angularity and threat, over time, could have become co-opted for social communication, such that specific facial expressions, head movements, or bodily behaviors that increase angularity became employed for threat signaling. Such signaling provides a displayer with the opportunity to provide a warning, and an observer with the opportunity to retreat. If such signaling does not occur, an agonistic encounter is likely to ensue, which can afflict physiological costs including pain, suffering, harm, or death, to both the displayer and observer. Signaling a threat intention and recognizing this intention in others therefore allows both the signaler and observer to avoid a costly and unnecessary agonistic encounter, resulting in a better outcome for the signaler and observer. Critically, for a hostile encounter to be avoided, the threat signal must be accurately interpreted by observers. Humans might have therefore engaged in a variety of different nonverbal behaviors in an attempt to communicate threat, but only those that increase angularity, and thereby capitalized on a broader cognitive association between angularity and threat, were accurately interpreted by observers, thus leading to mutually beneficial outcomes. Through this process, threat signals that increased angularity might have been selected over time as a result of their efficacy, whereas threat behaviors that did *not* increase angularity would have waned.

It is noteworthy that this perspective is a different than most accounts of the evolution of emotion expressions, such as Shariff and Tracy's (2011) Two-stage model. In their model, emotion expressions are originally adaptative for the *displayer*, regardless of any communicative properties; for example, disgust expressions function to close orifices to avoid a potentially dangerous disgust-eliciting stimulus, and fear expressions function to open the eyes wide which increases visual sensitivity (at the cost of acuity) to sense a fear-eliciting stimulus (Chapman, Kim, Susskind, & Anderson, 2009; Chapman & Anderson, 2013; Shariff & Tracy, 2011; Susskind et al., 2008). From this two-stage perspective, emotion expressions began as cues—providing information to those who happen to observe a displayer's internal state, but not existing for that reason. Eventually, however, these cues became transformed through the process of ritualization, such that they were exaggerated and became social signals, and this interpersonal signaling function became more important than the original physiological one (Shariff & Tracy, 2011). In the case of threat signaling with a dominance display and perhaps even an anger expression, however, the expressions might have evolved initially not for any internal function benefiting the *displayer*, but instead for the sake of communication, by scaffolding onto observers' pre-existing cognitive framework and associations, along with their tendency to show behavioral responses that resulted in mutually adaptive affordances to the displayer and observer (i.e., deference and submission).

Supporting this account, and consistent with the notion that visual angularity is critical for threat communication, angular geometric shapes (e.g., the letter "V" versus the letter "O", or "\/" shapes versus "//" and "\\" shapes) have been associated with increased threat and danger (e.g., Franklin, Adams, Steiner, & Zebrowitz, 2018; Lundqvist, Esteves, & Ohman, 1999; Aronoff, Woike, & Hyman, 1992; Armbruster, Suchert, Gartner, & Strobel, 2014; Bar & Neta, 2007; Weisbuch, Reynolds, Lamer, Masako, & Toko, 2020). For example, in one study participants were found to show greater amygdala activity – a brain region associated with a fear response – when shown real-world or researcher-generated objects with sharp angular contours, compared to objects curved contours (Bar & Neta, 2007). In the specific case of face perception, a study found that artificially removing all naturally occurring angular geometric lines caused prototypical expressions of anger to be perceived as less angry (Franklin, Adams, Steiner, & Zebrowitz, 2018).

The suggestion that angularity guides perception of threat from facial expressions opens the door to a follow-up question that could revolutionize our entire understanding of threat communication: Is activation of the corrugator muscle essential to communicate threat? The established perspective of the field is that this behavior (also known as AU 4) communicates anger, yet it is possible that the corrugator is not actually what is critical, but rather the visual characteristics that result from corrugator activation (i.e., *angularity*) are. If this account is correct, expressions that increase facial angularity but do not include corrugator activation should still communicate threat, and "*the*" prototypical expression of anger might in fact be *one* of *many* facial expressions of anger, all of which could be universal if they build upon a more ancient association between angularity and threat.

If this account is empirically supported, it could have three major implications for our understanding of emotion communication and social perception: (1) the use of EMG or FACS to assess corrugator activation as an emotional read-out of anger would be inconclusive or insufficient, (2) prior research on the form, antecedents, and consequences of anger expressions would have measured merely one of the many flavors of anger expressions, thus failing to capture the whole story, and (3) other flavors of anger facial expressions – especially expressions that increase eyebrow V-shape to a greater extent than corrugator muscle activation – might be perceived as even *more* angry than a prototypical expression of anger. This final point is supported by Studies 10-12 here, which showed combining a downwards head tilt with a prototypical expression of anger increases the perceived intensity of the expression, by virtue of causing the eyebrows to take on a more intense angular V-shape appearance *that is not caused by any additional corrugator activation*.

No prior research, to my knowledge, has proposed a prototypical expression of anger that does not include activation of the corrugator muscle. Yet, based on this account, the expression presented in Figure 38 (AUs 1+2+5+9+23/24) could be one example of such an expression; this combination of behaviors causes the eyebrows to take on an intense V-shape but does *not* include corrugator activation. Instead, this expression includes a combination of muscle activations associated with surprise (e.g., AUs 1+2+5) and disgust (e.g., AU 9). Therefore, if human threat perception is guided by activation of the corrugator muscle in particular, the expression in Figure 38 should *not* communicate threat, but instead be perceived as a blend of disgust and surprise (e.g., surprised disgust, disgusted surprise; Du, Tau, & Martinez, 2014), or as meaningless nonsense. However, if human threat perception is guided by angularity, and not by particular muscle activations, the expression in Figure 38 could communicate anger.

Figure 38. Expression that includes AUs 1+2+5+9+23/24

Universal threat perception, and understanding cultural differences

If humans possess an evolved cognitive association between angularity and threat, this association is likely to be a universal feature of human cognition, and could therefore be responsible for perceptions of threat formed from nonverbal behaviors across cultures. Although studies have not yet tested whether the association between angularity and threat is a universal feature of human perception and cognition, past research has shown that humans universally associate certain geometric shapes with certain linguistic features. For example, humans across cultures associate angular and jagged shapes with *sharper* sounds like "kiki" or "takete", whereas round and bulbous shapes are associated with sounds like "Maluma" or "Bouba". This effect is considered to be a functional universal (Heine & Norenzayan, 2005), meaning that the association is thought to exist in humans everywhere, but its strength varies across cultures (Ramachandran & Hubbard, 2001; Styles, 2017; Imai & Kita, 2014). More specifically, studies have found that this association is present among infants (Ozturk, Krehm, & Vouloumanos, 2013), young children (i.e., 2.5 years old; Maurer, Pathman, & Mondloch, 2006), congenitally blind individuals (via touch; Fryer, Freemna, & Pring, 2014), and members of a small-scall society with minimal exposure to Western culture (Bremner, Caparos, Davidoff, de Fockert, Linnell, & Spence, 2013). Given this evidence for a universal association between geometric shapes and language, it is reasonable to hypothesize a similar functionally universal association between geometric shapes and cognitive concepts such as threat.

Furthermore, if corrugator activation and a downwards head tilt increase perceptions of threat by virtue of increasing facial angularity, cultures with weaker associations between angularity and threat might show lower recognition rates of the anger expression, or of a downwards head tilt as conveying dominance. Stated differently, if the association between angularity and threat is foundational for recognizing threat displays, cultural differences in the association between angularity and threat could index cultural differences in the ability to recognize threat displays. As a result, in addition to explaining why anger and dominance are recognized across cultures at levels greater than chance, angularity could also explain why precise levels of recognition vary across cultures. Consistent with this expectation, the Songe of the Northern District of Papau New Guinea hold weaker associations between angular objects and the word "Tatake," when compared to WEIRD cultures (e.g., Rogers & Ross, 1975), and similar populations in Papau New Guinea hold weaker associations between expressions featuring AU4 and concepts of threat, such as anger (again, compared to WEIRD cultures; e.g., Ekman & Friesen, 1974; Ekman, 1995; Gendron, Crivelli, & Feldman-Barrett, 2018). In future research I plan to test whether humans across cultures associate angularity with threat, and, if so, whether this association might be responsible for the formation of threat perceptions resulting from AU4 and a downwards head tilt across cultures. This future research will address the question of *why* expressions of anger and dominance are universal threat signals, by examining whether they leverage a deeper evolved association between angularity and threat.

It is noteworthy that angularity and corrugator muscle activation are not necessarily mutually exclusive features guiding perceptions of threat; angularity in general *and* corrugator muscle activation in particular might simultaneously but independently influence these, such that activating the corrugator muscle has an effect over-and-above its effect due to increasing facial angularity. In fact, one possibility is that the specific contribution of activating the corrugator muscle (independent of increasing angularity) on threat communication is a culturally constructed phenomenon, whereas the broader association between angularity and threat is an evolved feature of human communication that guides threat perception universally. In theory, this could explain why the prototypical expression of anger is recognized at much higher rates in WEIRD cultures compared to small-scale societies, whereas a downwards head tilt – an expression with increased eyebrow angularity but no corrugator muscle activation – was recognized as similarly (or more) dominant among the Mayangna (84%, Chapter 3) compared to a US MTurk sample (78%, Study 10, Chapter 1), using identical methods and stimuli. Stated differently, recognition among WEIRD populations could be founded on (1) a (functionally) universal association between angularity and threat, and (2) an additive effect of a culturally specific association between activation of the corrugator muscle and threat perception, whereas non-WEIRD populations might only hold the former – a universal association between angularity and threat, but no culturally specific association between corrugator muscle activation and threat. If there does exist cultural variation in the association between angularity and threat, this account would yield a pattern of recognition very similar to that observed in cross-cultural research on emotion recognition: a prototypical expression of anger that is recognized at high rates in Western cultures (e.g., 80-90%), but at more moderate and variable, though still significantly greater than chance levels, among cultural groups that do not have an association between corrugator activation and anger, and/or hold a weaker association between angularity and threat.

Could AU4 be a head tilt imposter?

One possibility, consistent with the angularity account, and a culturally specific association between activation of the corrugator muscle and threat perception, is that using a downwards head tilt to communicate threat emerged early in our evolutionary history, whereas the use of corrugator muscle activation to send the same message evolved later in phylogeny to mimic the appearance cues and social-perceptual consequences of a downwards head tilt. Consistent with this possibility, several species across the animal kingdom engage in "head-down" behaviors to signal dominance or agonistic intent, including Rhesus monkeys (Altman, 1962; De Waal, Van Hooff, & Netto, 1976), a variety of ungulates (antelope, chamois, oryx, rams, gazelles, and waterbucks – including hornless female ungulates who are not merely using their horns as a weapon; Lott, 1974; Walther, 1974), ants (De Vroey & Pasteels, 1978), sheep, (Schaller & Beg Mirza, 1974), birds (Scott & Grumstrump-Scott, 1983; Mahoney, Threlfall, 1982), and fish (Reddon, O'Connor, Marsh-Rollo, Balshine, Gozdowska, & Kulczykowska, 2014; Neil, 1984; Burks, Scantland, Sinclaim, & Woolpy, 1985).

Chimpanzees – one of our closest phylogenetic relatives– do not have a corrugator muscle (Waller et al., 2006; Vick, Waller, Parr, Smith-Pasquialini, & Bard, 2006), consistent with the suggestion that the ability to create V-shaped eyebrows by moving facial muscles alone emerged later in phylogeny. It is currently unknown whether chimpanzees use a downwards head tilt to communicate anger or dominance, but there is evidence to suggest that chimpanzees communicate dominance from bodily behaviors in similar ways as humans do (e.g., with open and expansive nonverbal behavior – the opposite of closed and contracted nonverbal behavior; Goodall, 1986; de Waal, 2007; Tracy, 2016). In future research I plan to study the evolution of facial eyebrow musculature alongside cross-species communication of social rank, to determine whether the corrugator muscle evolved later in phylogeny than the use of a downwards head tilt to signal threat, and, if so, whether the corrugator muscle might have evolved specifically to serve a social communication function. Although past research has demonstrated that human bone structure, particularly the frontal bone (i.e., the brow ridge underlying the eyebrows), evolved for social communicative purposes (Godinho, Spikins, & O'Higgins, 2018), research has not explored whether head position, or visual angularity, and the social messages they send, have played a role in shaping the physiology and musculature of the human face.

Limitations

The current set of studies suffers from several limitations, which should be addressed in future research. First, as long as eye gaze was directed towards the observer, a downwards head tilt was always found to increase perceptions of dominance and anger, making the *closed and contracted*, *size of the chin/eyes,* and *Noh mask* mechanisms – all of which propose that a downwards head tilt is likely to *decrease* perceptions of dominance – not viable. One possibility, however, is that these mechanisms guide perceptions formed from a downwards head tilt when eye gaze is averted downward. As discussed in Study 3, when eye gaze was averted downward while the head was also tilted down, a downwards head tilt no longer increased perceptions of dominance (also see Toscano et al., 2018). Although the action unit imposter mechanism explains perceptions formed from a downwards head tilt when eye gaze is directed towards an observer, future research is needed to examine the visual mechanisms that guide social perceptions when eye gaze is averted downward. Eye gaze direction is a substantive behavior that has a large effect on perceptions of others' intentions (Calder et al., 2002), mental states (Fernandez-Duque & Baird, 2005), and future behaviors (Nummenmaa, Hyönä, &

Hietanen, 2009), and can mobilize observers to engage in social behaviors (Khalid, Deska, & Hugenberg, 2016; Adams & Kleck, 2005; Adams, Pauker, & Weisbuch, 2010; Hess, Adams, & Kleck, 2007). Therefore, any perceptual effects of averted eye gaze might overwhelm the signal communicated from a downwards head tilt such that the effect of head tilt is no longer salient when eye gaze is averted.

Second, although the action unit imposter effect explains why a downwards head tilt increases perceptions of dominance, it is unlikely to explain why an upwards head tilt also influences social perceptions. In Studies 1 and 2 an upward head tilt increased the perception of dominance (also see Chiao, Adams, Tse, Lowenthal, Richeson, & Ambaday, 2008), yet, based on the action unit imposter account, this behavior should *decrease* the eyebrow V-shape, and therefore decrease perceptions of dominance. In fact, tilting the head up should cause the eyebrows to take on an apparent Λ-shape – a visual cue consistent with AU1 (inner brow raiser), part of the prototypical expression of sadness, a display that should, in turn, decrease perceptions of dominance.

However, there are several mechanisms that might explain the positive effect of an upwards head tilt on perceptions of dominance. First, the visible FWHr, size of chin/eyes, and the open-and-expansive (i.e., the opposite of closed-and-contracted) mechanisms could each explain this effect. Although research is needed to test the distinctive contribution of each of these three mechanisms for guiding perceptions of dominance from an upwards head tilt, there is reason to believe that an upwards head tilt might function as an open and expansive behavior (i.e., the opposite of a closed and contracted nonverbal behavior), in particular. In a study examining the nonverbal communication of dominance and prestige (Witkower et al., 2019), individuals engaging in open and expansive nonverbal behaviors (e.g., arms out, arms up, body occupying much room) during a collaborative group task were very likely to also tilt their head upward throughout that task, $r = .83$, but much more modestly likely to tilt their head down, $r = .20$ (Witkower, Tracy, Cheng, Henrich, 2020). This finding might indicate that an upwards head tilt functions as part of a broader suite of expansive behaviors, even though, based on the findings in the current dissertation, a downwards head tilt does *not* function as a closed-and-contracted behavior. Critically, however, the finding that nonverbal displayers utilize an upwards head tilt in concert with expansive behaviors does not necessarily mean that perceivers use expansiveness as the visual mechanism to guide their perceptions. For example, an upwards head tilt might be used to communicate open-and-expansiveness by displayers, but observers exposed to this behavior might not perceive it as such, instead interpreting it as part of a different suite of behaviors that also increase perceptions of dominance (e.g., presence of a larger chin, or a costly behavior that exposes the neck). Future research is therefore needed to test how and why observers form perceptions from an upwards head tilt.

Conclusion

In the present dissertation, I argued that head position plays a critical role in face perception by causing the appearance of the eyebrows to change— paralleling the consequences of AU4 activation— without using facial musculature. This effect, called the action unit imposter mechanism, guides perceptions formed from expressionless (i.e., neutral) and emotionally expressive faces (e.g., anger, happiness), for individuals across cultures, and is therefore likely to be a universal feature of human communication. Together, findings indicate that social judgments about expressive or expressionless faces are driven not only by facial shape and musculature, but also by movements in the face's physical foundation: the head.

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[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.

[2]When referring to V-shaped eyebrows caused by corrugator activation, I mean unencumbered corrugator activation that is not altered by activation of frontalis (i.e., AUs 1 or 2). This is the apparent V-shape of the eyebrows caused by a downward head tilt is consistent with corrugator activation only if these additional action units are not present.

[3] I included an additional trial, not reported here, in which I showed participants a smiling expression with the head level and head tilted down, and asked them to select the image in which the person was experiencing more intense "pleasure at the misfortune of another". This trial was included to address a separate theoretical question, outside the scope of the current paper. For more details on results from this trial, the next chapter.

[4] Slight activation of AU7 (orbicularis oculi, pars palebralis) emerged, incidentally, in happiness expressions, in addition to AU6. This commonly occurs in intense happiness expressions, as activated muscle fibers can spread to each other and cause coactivation.

[5] FACS coding is a tool to characterize movement, and although the classification tool largely focuses on facial muscle activations, the existence of a FACS code does not necessitate that a *facial* movement is occurring. For example, there are FACS codes for *no* movement (i.e., AU 0), head movement (e.g., AU 54), eye movement (e.g., AU 63), shoulder and body movement (e.g., AU 82), and even when parts of the face are not visible (e.g., AU 70).

[6] I inadvertently neglected to instruct this graphic artist to ensure that alterations were not made to the appearance of the eyebrows in the process of photo editing. As a result, given that his main goal was to ensure that copied eyebrows appeared compatible with the face they were superimposed onto, it is possible that minor alterations were made to brow furrowing. Such changes were barely perceptible; nonetheless, I endeavored to address this possible limitation in Study 3.

[7] In fact, the effect reversed, with perceptions of anger *decreasing* in response to the tilted head. Importantly, this reversal did not emerge in Study 3, which utilized a wider variety of targets, so I am hesitant to interpret it any further.

[8] Two participants reported inaccurate ages (e.g., 53719 years old); their responses for this question were removed.
[9] I did not code or measure the head tilt in neutral displays, but there is good reason to assume that no tilt was present. These images are reliably perceived as neutral (Olszanowski et al., 2015), and slight head movements (as few as ten degrees either up or down) would likely have a strong effect on social perceptions even of neutral faces; prior research has shown that this movement causes neutral faces to be perceived as threatening, high status, and dominant (Witkower & Tracy, 2019; Witkower, Cheng, Tracy, & Henrich, 2019; Mignault & Chaudhuri, 2003; Hehman et al., 2013).
[10] Including random slopes for each emotion expression led to a singular fit so random slopes were removed from all models (Barr, Levy, Scheepers, & Tily, 2013). Follow-up cross-classified multilevel models including random effects for coders were constructed, and uncovered the same fixed-effect pattern. Given that only two coders assessed head angle, I could not appropriately estimate cross-rater variability, so I report multilevel models with observations nested within targets as my main analysis. An additional model with target gender included as a level-2 covariate did not alter the effect.
[11] This study was part of a larger study exploring how head tilt alters perceptions of a wide variety of emotion expressions (see Witkower & Tracy, 2020). All effects pertaining to schadenfreude have not been reported elsewhere.
[12] Slight activation of AU7 (orbicularis oculi, pars palebralis) emerged incidentally in happiness expressions, along with AU6. This commonly occurs in intense happiness expressions, as activated muscle fibers can spread to one another and cause coactivation (Danvers & Shiota, in prep).
[13] All pairwise comparisons throughout the paper are Bonferroni corrected for 7 groups (6 comparisons) when applicable. All effect size estimates for repeated measures are calculated based on Lakens (2013).
[14] For more information on translation and back-translation procedures, please contact the first author.