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BRIEF REPORT

Transforming the Mirror: Power Fundamentally Changes Facial Responding to Emotional Expressions

Evan W. Carr, Piotr Winkielman, and Christopher Oveis
University of California, San Diego

Major theories propose that spontaneous responding to others' actions involves *mirroring,* or direct matching. Responding to facial expressions is assumed to follow this matching principle: People smile to smiles and frown to frowns. We demonstrate here that social power fundamentally changes spontaneous facial mimicry of emotional expressions, thereby challenging the direct-matching principle. Participants induced into a high-power (HP), low-power (LP), or neutral state watched dynamic happy and angry expressions from HP and LP targets while we measured facial electromyography (fEMG) over the *zygomaticus major* ("smiling muscle") and *corrugator supercilii* ("frowning muscle"). For smiling, LP participants smiled to all targets, regardless of their expression. In contrast, HP participants exhibited standard smile mimicry toward LP targets but did not mimic the smiles of HP targets. Instead, HP participants smiled more when those HP targets expressed anger. For frowning, all participants showed a more intense mimicry pattern to HP targets. These results demonstrate that spontaneous facial responding—detected by sensitive, physiological measures of muscle activation—dynamically adapts to contextual cues of social hierarchy.

Keywords: emotions, facial expressions, electromyography, power, status

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Mimicry, the process of replicating others' actions, facilitates social bonds. Individuals experience greater rapport with their interaction partner both when they are mimicked and when they themselves mimic the partner (Chartrand & Van Baaren, 2009). Mimicry influences a variety of social judgments like trust, competence, and interpersonal similarity (Guéguen & Martin, 2009; Kavanagh, Suhler, Churchland, & Winkielman, 2011). Interestingly, mimicry can occur spontaneously, appearing anywhere from a second (e.g., finger mimicry; Leighton, Bird, Orsini, & Heyes, 2010) to several seconds (e.g., postural mimicry; Tiedens & Fragale, 2003) after stimulus onset.

Many major mimicry theories assume the *direct-matching principle*: Simply put, perceivers reproduce, with their own motor behavior, what they observe. Presumably, these direct mimicry effects result from the operation of low-level mechanisms like preformed perception–action links and visuomotor priming (e.g., Cook, Johnston, & Heyes, 2013) or higher-level mechanisms like embodied simulations used to faithfully recreate others' mental states to facilitate understanding (Goldman & Sripada, 2005). Here, we show that power fundamentally modifies mimicry in a manner that challenges the direct-matching principle.

Facial Mimicry and Direct Matching in the Social Context

One crucial imitative social behavior is spontaneous facial mimicry. It is generally assumed that facial mimicry involves *mirroring,* thus following a direct-matching principle: People smile in response to smiles and frown in response to frowns. Indeed, within typical lab settings, normal adults spontaneously respond with stimulus-congruent expressions, even when they are presented subliminally (Dimberg, Thunberg, & Elmehed, 2000). Such direct matching may often be functional by facilitating emotional contagion, enhancing emotion recognition, and signaling similarity (Niedenthal, Mermillod, Maringer, & Hess, 2010; Oberman, Winkielman, & Ramachandran, 2007). Consequently, standard motor-matching theories of mimicry—for example, the affiliation account (Chartrand & Bargh, 1999), the associative sequence learning account (Cook et al., 2013), the perception–action model (Preston & de Waal, 2002), and the affect-matching account (Dimberg et al., 2000) all assume that direct matching is the perceiver's default behavior in social situations.

Recent research has demonstrated, however, that mimicry is readily modified by social factors. For example, finger imitation is increased by prosocial priming (Leighton et al., 2010), whereas

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Evan W. Carr and Piotr Winkielman, Department of Psychology, University of California, San Diego; Christopher Oveis, Rady School of Management, University of California, San Diego.

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Correspondence concerning this article should be addressed to Evan W. Carr, Department of Psychology, University of California, San Diego, 9500 Gilman Drive #0109, La Jolla, CA 92093. E-mail: ewcarr@ucsd.edu

facial mimicry is reduced by outgroup membership (Bourgeois & Hess, 2008), negative attitudes (Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008), and competition (Weyers, Mühlberger, Kund, Hess, & Pauli, 2009). These findings suggest that facial mimicry is sensitive to contextual cues, basic appraisals, and rudimentary goal processes (Hess & Fischer, 2013).

Power May Moderate Direct Matching of Emotions

Power profoundly impacts the social context: It pervades and guides human relationships, exerting top-down influences on social cognition and behavior (Keltner, Gruenfeld, & Anderson, 2003). We propose that an analysis of the current literature suggests that power—of the emotion observer (perceiver) and the emotion expresser (target)—should modify direct matching of facial expressions for two reasons.

First, major power theories assume that social responding is interactive, because it depends on the relative relationship between the perceiver and target. With emotion, the perceiver's specific response to the target's expressive display should be shaped by the power level of both individuals within the interaction. This general, interactive prediction can be derived from many power theories: For example, in the situated focus theory of power, high-power perceivers are assumed to react in a flexible, goal-congruent manner to the target's power state (Côté et al., 2011; Guinote, 2010). According to the power-as-control theory, high-power perceivers engage in little modification of their behavior when dealing with low-power targets (because of reduced social dependency) while dynamically adapting their responses to high-power targets (Fiske, 1993). In sum, this interactive pattern, assumed by many power theories, predicts that spontaneous emotional responses should be adaptively adjusted in the social context (particularly for high-power perceivers).

Second, studies focusing on power in conjunction with emotional perception and responding suggest that these interactive effects (between perceiver and target) should depend on the specific emotion (Keltner et al., 2003). Regarding perception, for example, negative emotions (especially anger) of high-status targets are highly salient, presumably because of the association between anger and dominance (Hareli, Shomrat, & Hess, 2009; Tiedens, 2001). Regarding responding, for example, smiling is preferably used to regulate status in social relationships, perhaps because of greater flexibility and control of that expression (Keltner, Young, Heerey, Oemig, & Monarch, 1998; Niedenthal et al., 2010). Moreover, perceivers may implicitly up- and down-regulate different emotions in the presence of high- and low-power targets (Gyurak, Gross, & Etkin, 2011).

In short, current theories converge on the general prediction that both perceiver and target power should matter (along with the specific target emotion) in determining the perceiver's appropriate expressive response. Therefore, we hypothesized that mimicry would not follow the direct-matching principle but would instead be moderated by top-down contextual cues of hierarchy. This hypothesis is broad, but note that although some power theories offer detailed predictions about how exactly the perceiver's and/or target's power states should influence mimicry, their predictions often conflict. Further, no theory offers a full pattern of predictions for all of the factors investigated here. Critically, though, all power theories agree that there should not be universal direct matching when hierarchical cues are made salient. We return to the specific nature and mechanisms of these effects in the General Discussion section.

Current Research: A Psychophysiological Investigation of Power and Mimicry

Method

Stimuli selection and validation. Facial stimuli were eight videos from the MMI Facial Expression Database (Pantic, Valstar, Rademaker, & Maat, 2005) showing one of four individuals (two men, two women) displaying one of two emotions (happiness or anger) classified using the traditional Facial Action Coding System (Ekman & Friesen, 1978). We also wanted to ensure that specific timing and intensity values were comparable on the critical facial action units (AUs): AU4 (corrugator) and AU12 (zygomaticus).[1] Thus, all videos were processed frame by frame by Computer Expression Recognition Toolbox (CERT), which provides continuous support vector machine (SVM) activations over time for different AUs (Littlewort et al., 2011). SVM outputs for AUs 4 and 12 were evaluated using repeated-measures linear mixed-effects (LME) modeling—the same method used to analyze participants' fEMG data.[2] In short, our analyses found that the video stimuli were properly coded and standardized, particularly on the main muscles of interest (see the supplemental materials).

Participants and procedure. Fifty-five University of California, San Diego, undergraduates participated for course credit (82% women; $M_{\text{age}} = 20.5$ years, $SD_{\text{age}} = 3.06$ years). We first manipulated perceiver power by randomly assigning participants to complete either a 10-min high-power (HP; $n_{\text{HP}} = 19$), low-power (LP; $n_{\text{LP}} = 18$), or neutral ($n_{\text{control}} = 18$) writing prime (see the supplemental materials; Galinsky, Gruenfeld, & Magee, 2003). Next, fEMG electrodes were placed unilaterally on the left side of the face over the *zygomaticus major* ("smiling muscle" that pulls up the corners of the mouth) and *corrugator supercilii* ("frowning muscle" that furrows the brow; Tassinary, Cacioppo, & Vanman, 2007).[3]

Participants then observed videos in which four different targets were either happy or angry. We manipulated target power by

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[1] Note that CERT was only used to code the facial expression dynamics of targets in our stimuli (to further validate and standardize the videos). The main study used facial electromyography (fEMG) to gauge facial reactions of our participants in response to those CERT-validated videos.

[2] Linear mixed-effects (LME) modeling via restricted maximum likelihood was used for all repeated-measures analyses to reduce information loss when evaluating our large, unbalanced data sets after signal standardization (Judd, Westfall, & Kenny, 2012). All models were built using the lme4 package in *R* (Bates, 2005) with a maximal random-effects structure, after which stepwise likelihood ratio χ^2 significance tests were used to optimize model fit (West, Welch, & Galecki, 2007). All degrees of freedom were calculated using the Kenward-Roger method (CERT: Akaike information criterion corrected for finite sample size [AICc] = 2,089, Bayesian information criterion [BIC] = 3,356; zygomaticus: AICc = −685, BIC = 141; corrugator: AICc = −1,980, BIC = −1,086; cross-muscle comparison: AICc = −394, BIC = 34).

[3] Skin conductance response was also measured to evaluate sympathetic nervous system activity, but this only yielded a main effect of time, $F(9, 468) = 1.97$, $p = .04$, indicating that participants had a general arousal response to the stimuli. No other effects were found, so skin conductance response is not discussed further.

randomly pairing each target with an HP profession (physician or senior executive) or an LP profession (fast food worker or grocery store stocker). Before each block, participants saw a neutral picture of the target (with his or her respective profession) and instructions to "just observe each video closely, and press the space bar as fast as you can when each video starts to play."

Each trial lasted 5,000 ms (3,000 ms pretrial fixation)—with the target's name and profession subtitled—and participants were instructed to log a response at each video onset (response times [RTs] were recorded). We counterbalanced four blocks of 20 randomized video trials (10 angry and 10 happy), totaling 80 fEMG trials (see Figure 1).

Last, mood was assessed using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), and participants reported what they thought the experiment was investigating.[4]

Results and Discussion

Controls and manipulation check. Two independent coders rated all essays for how much power or control was expressed on a 1 (*none at all*) to 7 (*very much*) scale ($\alpha = .71$). Results showed that our manipulation successfully varied the desired states across conditions, one-way analysis of variance (ANOVA), $F(2, 52) = 48.2$, $p < .001$, where LPs expressed the least power ($M = 2.76$, $SD = 0.91$), HPs expressed the most power ($M = 5.11$, $SD = 0.69$), and controls fell in between ($M = 3.39$, $SD = 0.63$), Tukey's honestly significant difference, $ps < .05$.

It is important to note that the perceiver-power manipulation did not change self-reported mood: One-way ANOVAs on the PANAS revealed no differences between perceiver-power conditions for positive affect ($M = 2.31$, $SD = 0.78$), $F(2, 52) = 0.52$, *ns*, or negative affect ($M = 1.51$, $SD = 0.52$), $F(2, 52) = 1.03$, *ns*.

During every trial, RTs were recorded to test whether the perceivers in each of the power conditions paid equal attention to the videos: Log_{10}-transformed RTs showed no differences by perceiver power, $F(2, 52) = 0.51$, *ns*. Moreover, no participant reported that the experiment was investigating mimicry. In sum, our power manipulation was successful, and our control measures suggest that mood, attention, and demand effects did not confound the effects.

Corrugator (frowning). Overall, perceivers responded to all targets' anger expressions with increased corrugator activity. More specifically, corrugator activity to anger was increased compared with baseline, $t(54) = 3.75$, $p < .001$, $d = 0.51$, with no such increase to smiles. Further, participants showed more corrugator activity to angry versus happy videos, as reflected in the main effect of valence, $F(1, 52) = 11.96$, $p = .001$, from the LME model (see footnote 2).

Critically, though, perceivers' corrugator responses to angry and happy videos were influenced by the target's power, as reflected in a Valence × Target Power interaction, $F(1, 52) = 6.87$, $p = .01$. Figure 2 shows that perceivers displayed a more differentiated mimicry pattern to HP than LP targets, and this pattern remained stable over the entire trial period. In particular, participants showed greater corrugator activity to angry versus smiling HP targets, $b = .11$, $t = 4.30$, $p < .001$, $d = 0.54$ (with no differences to LP targets). No main effects or interactions involved perceiver power.

Zygomaticus (smiling). On this muscle, we found that both perceiver and target power modify facial responding, as reflected in a three-way Perceiver Power × Target Power × Valence interaction, $F(2, 104) = 3.21$, $p = .04$ (see Figure 3).

First, LP perceivers smiled (as measured by increase from baseline) to all targets and expressions. That is, LP perceivers smiled to HP targets' smiles, $t(17) = 2.36$, $p = .03$, $d = 0.56$, and LP targets' smiles, $t(17) = 1.83$, $p = .08$, $d = 0.43$. It is interesting that LP perceivers also showed overall smiling toward the incongruent target expression (anger), $t(17) = 2.93$, $p = .01$, $d = 0.69$ (see Figure 3, left panel). More specifically, LP perceivers smiled to angry expressions of both HP targets, $t(17) = 2.11$, $p = .05$, $d = 0.50$, and LP targets, $t(17) = 3.15$, $p < .01$, $d = 0.74$. This pattern of greater smiling to anger is also robust when comparing LP perceivers with controls, $b = .14$, $t = 2.41$, $p = .02$, $d = 0.80$. In short, whether tested against the baseline or control participants, LP perceivers responded incongruently to angry facial expressions (i.e., by smiling).

Second, HP perceivers demonstrated the most clearly differentiated smiling patterns as a function of target power and valence (see Figure 3, right panel): Follow-up simple effects testing revealed that HP perceivers showed standard mimicry toward LP targets' smiles, significant above baseline, $t(18) = 2.96$, $p < .01$, $d = 0.68$.[5] HP perceivers did not mimic HP targets' smiles, $t(18) = 0.15$, $d = 0.03$, *ns*. In fact, not only did HP perceivers exhibit greater smile mimicry toward LP than HP targets, $b = .14$, $t = 2.37$, $p = .02$, $d = 0.61$, but in response to HP targets' anger expressions, HP perceivers actually smiled more, significant above baseline, $t(18) = 3.42$, $p < .01$, $d = 0.78$, and approaching significance compared with HP targets' smiles, $b = .12$, $t = 1.83$, $p = .07$, $d = 0.47$. In summary, HP perceivers did not mimic HP targets' smiles (compared with both baseline and LP targets), instead engaging an incongruent smiling response when those HP targets expressed anger.

Cross-muscle analyses. The just-presented analyses of the individual muscles confirm that power cues transform direct matching (e.g., smiling to anger expressions). However, this does not address whether any muscles were coactivated over the trial period. This question matters for interpreting situations in which individual muscles appear to be showing divergent responses to the same stimulus (e.g., for HP perceivers, increased smiling and increased frowning to angry HP targets). In essence, how is it possible to have an incongruent response on one muscle, with direct matching on another?

We investigated this in two ways: First, we tested for any simultaneous coactivation. Thus, we computed zero-lag cross-correlations (using the Pearson r method) between the corrugator and zygomaticus values for each participant at every factor level using the same 500-ms time windows (Orfanidis, 1988). Individual subject cross-correlations were converted to Fisher Z values, av-

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[4] Our PANAS mood measurement was placed at the end of the experiment to avoid demand effects. This structure was based on the assumption that mood states would not change dramatically from the start of the fEMG video clips (i.e., immediately after the perceiver-power manipulation).

[5] Within the three-way interaction from the LME model, when the data are tested using an ANOVA only within the HP-perceiver condition, this also results in a two-way Valence × Target Power interaction, $F(1, 18) = 5.76$, $p = .03$.

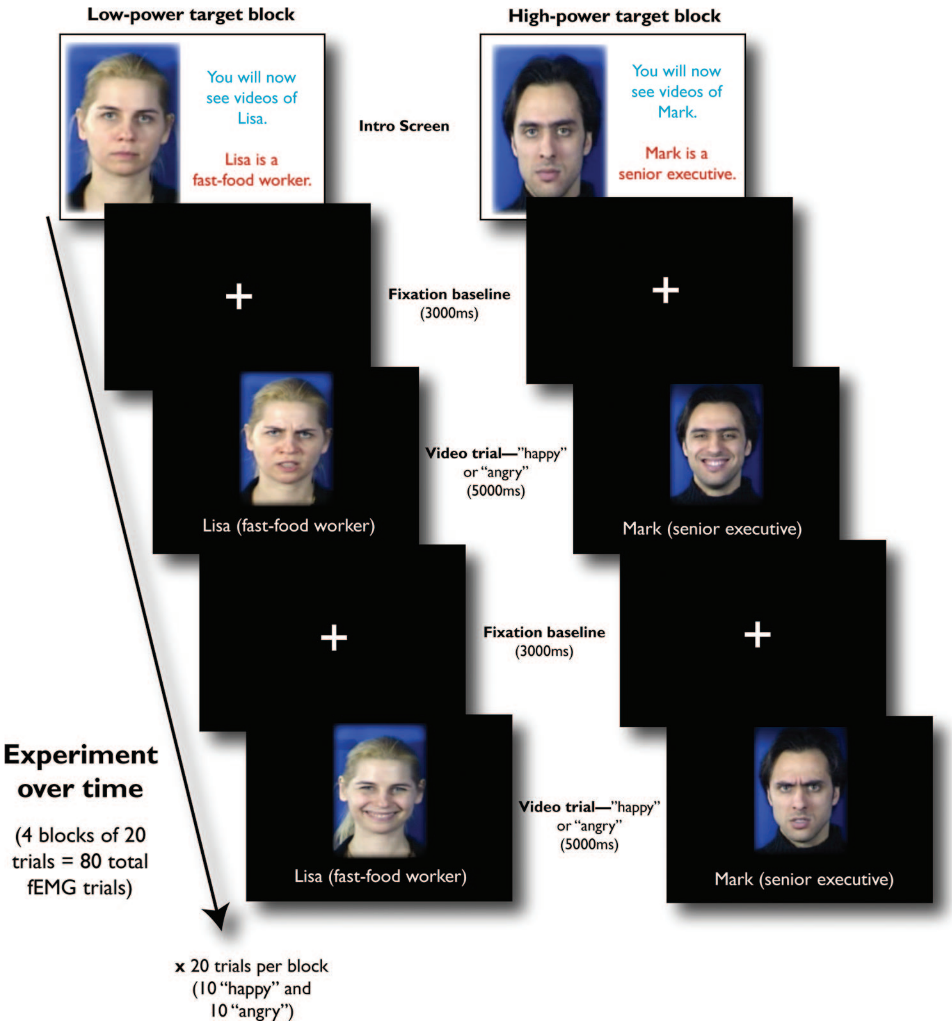

Figure 1. Experimental design from the main study. All participants completed 80 video trials (four blocks of 20 trials each; order randomized and counterbalanced), in which each target was paired with a high- or low-power profession in each block. Within each block, 10 trials were angry videos and 10 trials were happy videos. fEMG = facial electromyography.

eraged within each factor level, and then backtransformed into *r* values to compute 95% confidence intervals and significance tests (Silver & Dunlap, 1987). No condition (at any factor level) displayed a significant cross-correlation, and a majority of these *r* values were negative (see Table S1 in the supplemental materials).

Second, we tested whether participants activated individual muscles differently over time. We constructed an expanded LME model that included time and muscle as factors (because all fEMG activations were *z* scored within subject, this allows for cross-muscle comparisons). It demonstrated that during the trial period, all participants activated the corrugator earlier (before 1,000 ms), and the zygomaticus reacted later (2,000–4,000 ms; see Figure S1 in the supplemental materials).

In conclusion, facial muscles did not activate simultaneously but rather separately with muscle-specific time delays (corrugator was early and zygomaticus was late). We return to these important findings in the General Discussion section.

Follow-up Rating Experiment on Power and Smile Perception

Our main psychophysiological study demonstrated that power changes mimicry of emotional expressions, especially for smiles. We explored if this could be due to perceivers' different explicit interpretations of those smiles—a possibility given that smiles have many social meanings (Niedenthal et al., 2010). To investigate this, we conducted a follow-up experiment, where 69 University of California, San Diego, undergraduates (77% women, $M_{\text{age}} = 21.3$ years, $SD_{\text{age}} = 2.53$ years) rated and classified different smiles from our stimuli (target power counterbalanced) after the same perceiver-power manipulation. There were no differences based on perceiver or target power for smile classifications or intensities (see Table S2 in the supplemental materials), so the observed effects from the main study were not driven by differences in perceivers' explicit interpretations of those expressions.

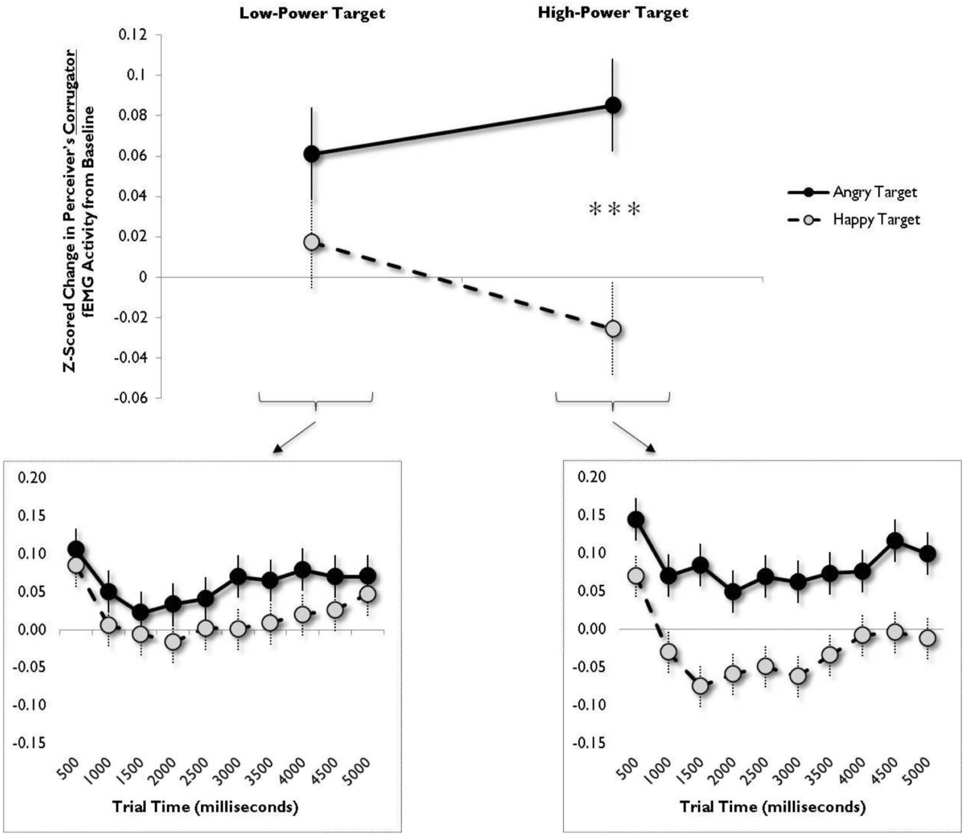

Figure 2. Corrugator facial electromyography (fEMG) results from the main study. A Valence × Target Power interaction revealed a more differentiated mimicry pattern toward high-power targets (compared with low-power targets), which remained stable over the entire trial period. Means are plotted in the top panel; the bottom panels display the mean signal across time. Error bars represent 1 standard error of the mean. Asterisks indicate significant comparisons. $^{***}p \leq .001$.

General Discussion

Facial expressions are major social stimuli, and understanding how and when mimicry occurs is essential for theories of imitation, affiliation, empathy, and embodiment (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005). Our experiments reveal that both perceiver and target power interact to influence spontaneous responding to positive and negative facial expressions. These findings underscore an important point: Even at the basic level of muscle activation, the widely assumed direct-matching principle does not hold, qualifying mimicry theories that assume a straightforward correspondence between what is perceived and what is produced.

We highlight three major theoretical points, based on our original hypotheses: First, as implied by major power theories, direct-matching responses were modified (and even reversed, in some cases) when hierarchical cues were made salient. Note these results cannot be explained by simple perceptual or attentional factors, which in some direct-matching theories are allowed to modify mimicry (e.g., the associative sequence learning account; Cook et al., 2013). After all, attention to the target was controlled for in the main study, and RTs showed no differences between the perceiver-power conditions. Instead, our results support socially driven views of emotional mimicry (e.g., emotional mimicry in context; Hess & Fischer, 2013) whereby mimicry serves as a "function of interaction goals, and a change of those goals, whether conscious or automatic, has an effect on whether people mimic others' emotions" (p. 153).

Second, these indirect-matching patterns were dependent on both perceiver and target power, demonstrating that the interaction of these states leads to different responses. As mentioned in the introduction, many modern power theories converge on this general prediction. For instance, within theoretical frameworks on competition (e.g., Weyers et al., 2009), an HP target's anger has a positive meaning for the HP perceiver (one's loss means another's gain), leading to a breakdown in direct matching. Alternatively, perceivers' emotional responses could result from shifts in cognitive flexibility or control. For example, the situated focus theory of power accounts for more selective responses from HP perceivers with their heightened ability to perceive, access, and use relevant contextual information in constructing social reactions (Guinote, 2010). Critically, though, although no modern power theory currently offers detailed enough constraints to predict the full pattern of our results, the present research is certainly consistent with the

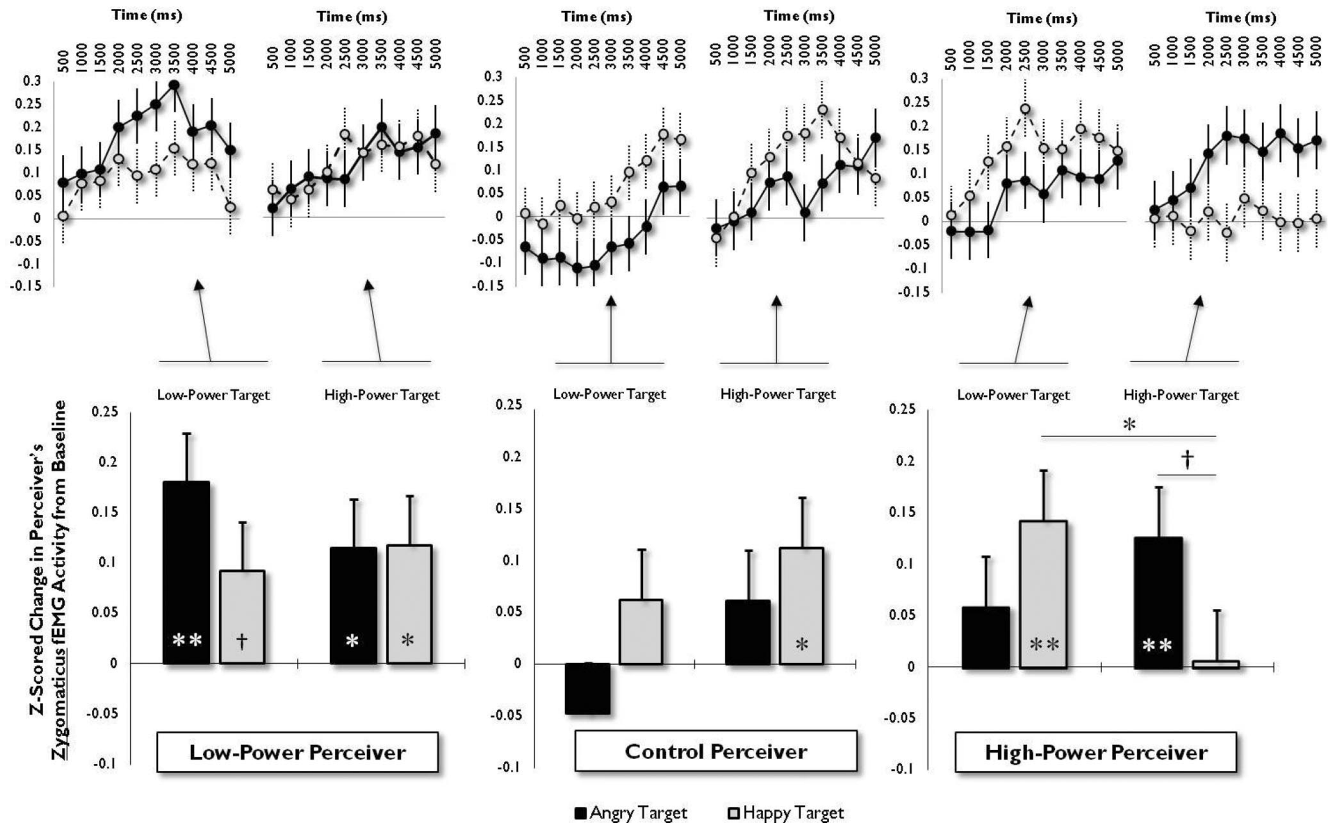

Figure 3. Zygomaticus facial electromyography (fEMG) results from the main study. A Perceiver Power × Target Power × Valence interaction showed that high-power (HP) participants mimicked smiles from low-power (LP) targets but reduced smiling mimicry toward HP targets (instead smiling more when those HP targets expressed anger). LP participants mimicked smiles, but they also smiled toward anger expressions, both compared with controls and compared with baseline. Time courses are displayed above each bar graph, which plot the overall means. Error bars represent 1 standard error of the mean. Asterisks within bars represent significance level compared with baseline, whereas those above brackets represent significant contrasts. $^{\dagger} p \leq .10$. $^{*} p \leq .05$. $^{**} p \leq .01$.

interactive spirit of those modern theories. And, most important, these results are the first to counter direct-matching frameworks that do not predict an interactive effect between both the perceiver- and the target-power states. In short, "power does not exist in a vacuum, [and it] is affected by both interaction partners' behavior and their mutual perception thereof" (Mast, 2010, p. 26).

Finally, our results show that power's effects on facial responding depend on specific emotion. Recall that perceiver power did not impact anger mimicry; only target power did (for all perceivers, mimicry toward HP targets' anger expressions was more differentiated). However, smile mimicry depended on both perceiver and target power. As such, our results are consistent with proposals that smiling responses are dynamic social signals that adapt to social context (Niedenthal et al., 2010). Researchers conducting future studies should uncover the exact mechanisms behind these smiling responses, but note that the context-driven nature of those smiling responses is also suggested by the fact that the zygomaticus reacted later (2,000–4,000 ms), compared with the immediate responses observed in the corrugator (before 1,000 ms). In fact, these timing differences suggest a possible reconciliation of direct and indirect facial mimicry perspectives, where early responses follow more direct-matching principles (with some salience-related modification), and later (while still spontaneous) responses reflect influences of the interaction context.

Generally, the current research demonstrates that power can cause direct matching to break down and, overall, that variables at the essence of social hierarchy seamlessly influence basic psychological functioning (Zajonc, 1998).

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