Psychophysiology, 46 (2009), 328–335. Wiley Periodicals, Inc. Printed in the USA.

DOI: 10.1111/j.1469-8986.2008.00771.x

Modulation of facial reactions to avatar emotional faces by nonconscious competition priming

PETER WEYERS,[a] ANDREAS MÜHLBERGER,[a] ANJA KUND,[a] URSULA HESS,[b] AND PAUL PAULI[a]

[a]Department of Psychology, University of Würzburg, Würzburg, Germany
[b]Department of Psychology, University of Quebec at Montreal, Montreal, Canada

Abstract

To investigate whether subliminally priming for competition influences facial reactions to facial emotional displays, 49 participants were either subliminally competition primed or neutrally primed. Thereafter, they viewed computer generated avatar faces with happy, neutral, and sad expressions while *Corrugator supercilii* and *Zygomaticus major* reactions were recorded. Results revealed facial mimicry to happy and sad faces in the neutrally primed group but not the competition primed group. Furthermore, subliminal competition priming enhanced *Corrugator supercilii* activity after an initial relaxation while viewing happy faces. An impression formation task revealed counter empathic effects confirming successful competition priming. Overall, results indicate that nonconscious processes influence a presumably nonconscious behavior.

Descriptors: Emotion, Facial expression, Subliminal priming, Competition, Facial EMG

Looking at an emotional face leads to congruent facial expressions in the observer's face (e.g., Dimberg, 1982, 1990; Dimberg & Thunberg, 1998), called *facial mimicry*. Viewing a happy expression is associated with increased *Zygomaticus major* activity (the muscle responsible for lifting the corners of the mouth upwards in a smile), whereas viewing negative expressions like anger and sadness is associated with increased *Corrugator supercilii* activity (the muscle responsible for drawing the eyebrows together in a frown). Facial mimicry is considered to be biologically based and an automatic and reflexlike reaction. That is, facial mimicry usually occurs rapidly and outside conscious awareness. Thus, Dimberg and Thunberg (1998) found mimicry onsets as quickly as 300–500 msec after stimulus exposure. Furthermore, mimicry reactions can be measured even after subliminal exposure (Dimberg, Thunberg, & Elmehed, 2000) and cannot be totally suppressed even if one is instructed to do so (Dimberg, Thunberg, & Grunedal, 2002).

Thus, facial mimicry is part of a group of nonverbal social behaviors that have been found to occur automatically and without conscious awareness or control (Bargh, 1990). Like the matching of behavior in posture and gesture—behavioral mimicry—among interaction partners (Lakin & Chartrand, 2003), congruent facial reactions are assumed to be a nonverbal social strategy to create empathy and liking (see also Chartrand & Bargh, 1999; Lakin, Jefferis, Cheng, & Chartrand, 2003). According to Hess (2001), congruent facial displays only occur if a positive or at least a neutral relation between interaction partners exists. Displays then serve communicative functions, for example, signal attention and understanding, to create comfortable interactions and to reinforce relationships. Yet another function could be that by facial mimicry the perceived facial expression is internally simulated and in this way the understanding of other people's emotions is facilitated (Atkinson & Adolphs, 2005; Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Wallbott, 1991). However, Blairy and colleagues (Blairy, Herrera, & Hess, 1999; Hess & Blairy, 2001) using more stringent experimental manipulations and mediational analyses did not find evidence for this notion, suggesting that there is no direct effect of facial muscle activity on emotion recognition.

Modulation of Facial Mimicry

Research on behavioral mimicry has documented several individual and situational influences, and generally it is assumed that facial mimicry is modulated in the same way by the same factors and processes as behavioral mimicry (for reviews see Chartrand & Bargh, 1999; Chartrand, Maddux, & Lakin, 2005). However, besides similarities, there are also some important differences. Thus, research on behavioral mimicry mostly focuses on behaviors such as crossing the legs, foot tapping, etc., that is, behaviors that do not convey emotional information. On the other hand, facial reactions to facial emotional stimuli convey emotional information. Specifically, emotional displays as reactions to facial emotional expressions can be the result of stimulus appraisal processes based on attitudes or concerning actual

We are grateful to Katja U. Likowski and two anonymous reviewers for valuable comments and suggestions. This work has partly been supported by the Deutsche Forschungsgemeinschaft (DFG).

Address reprint requests to: Dr. Peter Weyers, Department of Psychology, University of Würzburg, Marcusstr. 9-11, 97070 Würzburg, Germany. E-mail: weyers@psychologie.uni-wuerzburg.de

demands or information regarding one's own goals or intentions contained in the situational context (see also Hess, 2001). Just imagine, for example, the following situation: You meet a person you don't like at all, and at that moment there is no need for you to create a positive relationship. As a consequence you might not show congruent facial muscular reactions or your facial reactions might even show opposing tendencies, and this is exactly what has been found. Specifically, negative racial attitudes toward members of an ethnic out-group result in reduced facial mimicry to pictures of out-group members (Herrera, Bourgeois, & Hess, 1998). French Canadian participants correctly decoded the emotional facial expressions displayed by Japanese actors, but did not mimic their emotional expressions. Moreover, the more negative their racial attitude was in general, the more they tended to smile at sad and fear expressions and to frown at happy and angry expressions—a phenomenon called *counter mimicry*. Similar effects have been demonstrated for experimentally induced attitudes using computer-generated emotional faces (Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008) and artificial in-group/out-group distinctions (Bourgeois & Hess, 2008). One may speculate that by showing non matching behaviors indicating lack of empathy or rapport, an uncomfortable interaction is created "that the interaction partners may want to avoid in the future" (Hess, 2001, p. 406).

Furthermore, there is evidence that the situational context modifies facial reactions to facial emotional stimuli. Thus, experimental evidence for counter mimicry was provided by Lanzetta and Englis (1989). Lanzetta and Englis explicitly told their participants that in an investment game "The likelihood that you and your partner will be competitive is 82%" (Lanzetta & Englis, 1989, p. 547)—with the partner actually being a videotaped confederate. Their results did not only indicate various counter empathetic effects but also counter mimicry effects, that is, smiling at expressions of distress—a grimace, for the participant presumably caused by an electric shock—and frowning at expressions of pleasure. Note, however, that in this experiment counter mimicry was demonstrated in response to an explicit competitive interaction. Thus, the question still remains whether the mere priming for competition already modifies facial muscular reactions when confronted with emotional facial expressions from an unknown person.

Explicit and Implicit Goals and Motives

There is evidence that the motives or goals that are explicitly or implicitly activated in a given situation influence information processing as well as (social) behavior by narrowing attention and focusing it on goal relevant aspects of the situation (see Gollwitzer & Moskowitz, 1996) as well as by activating goal oriented action tendencies. Thus the same goal relevant perception processes and goal attainment related behavior can occur independent of the awareness of that goal (Chartrand & Bargh, 1996; see also Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001). In line with this, Lakin and Chartrand (2003) showed that both explicit and subliminal priming for need for affiliation intensified behavioral mimicry (gestures and postures). Whereas Lanzetta and Englis (1989) demonstrated that explicitly formulated situational conditions (e.g., a competitive situation) modified facial muscular reactions to facial expressions, it still remains to be shown whether they are also modified by goals or motivations that are activated outside of awareness.

Avatars as Research Tools

In the present research, we used avatars rather than photos in order to control for the modulating influence of variables like attractiveness, liking, etc. Avatars (a virtual person or graphic substitute for a real person) provide useful tools for research in emotion and social interactions (Blascovich, Loomis, Beall, Swinth, Hoyt, & Bailenson, 2002) since they allow full control over the facial expression and its dynamics, e.g., its intensity and temporal course (c.f. Krumhuber & Kappas, 2005). In addition, from an applied point of view the increased use of computer interactions with avatars, for example in business and entertainment, demands that we learn more about the cognitive and emotional elements of such interactions.

How successful an avatar can be used as interaction partner was recently demonstrated by Bailenson and Yee (2005). A digital chameleon, an avatar that mimics behavior, was rated more favorably by the mimicked human participant even though the participant was not aware of the mimicry. Thus, an avatar's mimicry served as a successful strategy to create liking—just as "in real life" (Chartrand & Bargh, 1999). We employed avatar facial emotional expressions created with *Poser* (*Curious Labs*, Santa Cruz, CA, USA) for the present study. Previous research has validated emotion recognition rates for *Poser* avatars (Spencer-Smith, Wild, Innes-Ker, Townsend, Duffy, Edwards, et al., 2001) showing that recognition was comparable to the Pictures of Facial Affect (Ekman & Friesen, 1976). Furthermore, comparable amygdala activation has been demonstrated in response to facial emotional expressions by *Poser* avatars and by humans (Moser, Derntl, Robinson, Fink, Gur, & Grammer, 2007).

Goals and Hypotheses of the Present Study

According to the reasoning outlined above, we investigated whether facial muscular reactions in response to facial emotional expressions can be modified by implicitly activated goals and motivations. As an explicit competition situation has been shown to lead to reduced or even counter mimicry (Lanzetta & Englis, 1989), we used an established subliminal priming procedure (see Bargh & Chartrand, 2000) to implicitly activate a competitive motivation in order to show a similar effect.

As a first approach, we studied facial muscular reactions to happy and sad facial expressions. These two emotional expressions were chosen because we wanted to use expressions similar to those used by Lanzetta and Englis (1989). However, instead of a grimace we presented sad facial expressions because we did not want to use a cover story including painful stimulation. Yet, just like a grimace a sad face indicates that the person is harmed by someone or something. Further, both expressions possess affiliative functions in social interactions and relationships (Knutson, 1996), are contagious (Jakobs, Fischer, & Manstead, 1997), and allow clear-cut predictions regarding the facial muscular responses. We predicted that competition priming suppresses affiliative and contagious tendencies and in fact may even lead to opposing tendencies, that is, to distancing from the opponent because the interaction partners hold conflicting interests. Thus, in the context of competition a happy face shown by an opponent signals that the person is doing well and is optimistically anticipating the competition, hence that person might have an advantage and be in the better position to win. Therefore, in response to an opponent's happy face the observer's *Zygomaticus major* (the muscle responsible for smiling) should not become activated but instead the person's *Corrugator supercilii* (the muscle responsible for frowning). Conversely, an opponent's sad face signals that the person might not do and/or feel well at the moment; hence the observer might have an advantage for the upcoming competition. Therefore, in response to an opponent's sad face the observer's *Zygomaticus major* activity should increase and the *Corrugator supercilii* should become relaxed.

Method

Participants

A total of 49 women, aged between 19 and 30 years ($M = 21.47$, $SD = 2.67$), participated in the experiment. The majority were university students, who received course credit. The others were recruited by internet advertisements and participated for the chance of winning 50€, for which lots were drawn after the experiment was finished. Recruitment was limited to female subjects because of earlier findings (Dimberg & Lundquist, 1990) indicating that women show more pronounced but not qualitatively different mimicry than men. Participants were randomly assigned to one of two experimental conditions.

Procedure

Participants were tested individually. They were informed that they would complete several unrelated computer tasks. After signing the consent form, the EMG electrodes were placed with the remark that skin conductance would be recorded.

The participants first completed a priming task. The priming task was presented as a visual attention and reaction time task using the procedure described by Bargh and Chartrand (2000). Participants saw either four words related to the concept of competition: *WETTBEWERB* (competition), *GEGNER* (opponent), *KONKURRENT* (rival), and *GEWINNEN* (win) or four neutral words: *NEUTRAL* (neutral), *STRASSE* (street), *HINTERGRUND* (background), and *TAFEL* (blackboard). Each word was presented 20 times in random order parafoveally for 90 ms at one of four possible locations on the screen and followed by a masking string of letters (*XQFBZRMQWGBX*). Participants placed their index fingers on two marked keys of a PC key pad in order to indicate as quickly and correctly as possible on which side of the screen a brief flash of light (actually the priming words) appeared.

For the second task, the experimenter explained that avatars are virtual characters who express the mood of a real person, for example, in a live online game and, as such, avatars serve the communication between people who in fact do not see each other. Participants were then asked to look at the avatars carefully since they would be asked some questions about them later on. Each avatar was presented for 8 s while *Zygomaticus major* and *Corrugator supercilii* activity were recorded.

This was followed by a manipulation check (see below). To keep the procedure plausible for the participants, they were also asked some questions about the avatars before the awareness check for the priming words was completed. For this, the experimenter explicitly told the participants that in the following task words would be presented on the screen for only a very short period of time, and they should try as hard as possible to recognize the words. Then the experimenter again presented each priming stimulus with the masking string of letters on all of the four possible locations on the screen, and participants were asked to repeat what they believed they had seen. No participant correctly recognized any of the stimulus words.

After the electrodes were removed, participants completed the SPF (Paulus, 2000) and the EPQ-RK (Ruch, 1999) and were probed regarding suspicions about the true purpose of the experiment. No one was aware of the priming task or suspected that facial muscular reactions were measured.

Stimuli

Poser (*Curious Labs*, Santa Cruz, CA, USA) allows the creation of computer-generated facial expressions in an easy and controlled way, and Spencer-Smith et al. (2001) offered a software extension to manipulate facial expressions based on the Facial Action Coding System (FACS; Ekman & Friesen, 1978). Three emotional facial expressions were created from a prototype female face: a neutral, a happy, and a sad expression (for details see Spencer-Smith et al., 2001). Each expression was combined with three different hairstyles (blond, middle length hair; brown, long hair; black, short hair), resulting in nine stimuli (3 emotional expressions × 3 hairstyles; for examples, see Figure 1).

The three stimuli showing the same facial expression were presented three times each blockwise, and six block orders were created. For each participant three blocks were presented, the order of the stimuli was varied within blocks, resulting in 27 picture presentations. The stimuli were presented for 8 s on a computer screen one meter in front of the participants with a picture size of 19 cm × 20 cm. They were preceded by a warning noise and a fixation cross in the center of the screen. Intertrial intervals varied from 25 to 31 s.

Dependent Measures

Facial EMG

Muscle activity was recorded over the *Zygomaticus major* and *Corrugator supercilii* regions of the left side of the face using

Figure 1. Examples for avatar emotional facial expressions.

bipolar placements of Ag/AgCl electrodes with a surface diameter of 7 mm (Fridlund & Cacioppo, 1986). The EMG raw signal was measured with a Neuroscan SynAmps amplifier, digitized using a 16-bit analog-to-digital converter, and stored with a sampling frequency of 1000 Hz. Raw data were filtered offline with a 30–500 Hz bandpass filter as well as a 50 Hz notch filter and then rectified. The data was integrated with a 125 ms time constant.

Difference scores were calculated using the last second before stimulus onset as baseline. Trials with EMG activity above 8 μV during the baseline period were scored as artefact (less than 5%). Prior to statistical analysis, data were collapsed over the 9 trials with the same emotional expression, and averaged over 1000 ms epochs.

Manipulation check

To assess the effectiveness of the priming task, the participants completed an impression formation task. They were asked to judge a neutral female face taken from the Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998; stimulus AF19NES) on 30 bipolar trait dimensions (e.g., likeable vs. unlikable, hostile vs. friendly; cf. Osgood, Suci, & Tannenbaum, 1957) with a seven-point bipolar scale (3-2-1-0-1-2-3). Numerous studies have shown priming effects using this procedure (for a summary, see DeCoster & Claypool, 2004). Subliminal competition priming as compared to neutral priming was expected to result in less favourable judgments on the dislikable/likable dimension (see Cacioppo, Priester, & Berntson, 1993, who used the unpleasant/pleasant dimension) and even more specifically on competition-related traits (hostile/friendly; disapproving/cooperative; stubborn/amenable).

Individual Difference Measures

Because there is evidence that high empathic or high extraverted subjects tend to show stronger facial reactions (Jäncke, 1993; Sonnby-Borgström, Jönsson, & Svensson, 2003), *Empathy* was assessed using the SPF (Paulus, 2000) and *Extraversion* using the EPQ-RK (Ruch, 1999) to control for group differences. There were no substantial differences between the two experimental groups regarding these variables (all p-s > .23).

Results

Manipulation Check

Consistent with the expectation of counter empathic effects, competition primed participants judged the target person generally as less likable than the neutrally primed participants. Furthermore, they judged her as being more hostile, more disapproving, and more stubborn (see Table 1). Note that the manipulation check was performed about 20 minutes after the priming task and the photograph of the stimulus person was visible for the whole time of the impression formation task, hence participants were able to make deliberative decisions.

Facial Reactions

A four-way factorial Group × Emotion × Muscle × Seconds repeated measures ANOVA was conducted. Interaction effects were followed up with simple effects ANOVAs. Greenhouse-Geisser corrections were applied if necessary. Group effects for a specific emotion–muscle combination were tested one-tailed, since we expected less mimicry or even counter mimicry with competition priming. The data for the emotions *happy*, *neutral*, and *sad* are shown separately in Figures 2, 3, and 4.

Evidence for emotion specific facial reactions was provided by significant Emotion × Muscle, $F(2, 94) = 10.9$, $p = .001$, $\eta_p^2 = .188$, and Emotion × Muscle × Seconds interactions, $F(14, 658) = 3.6$, $p = .002$, $\eta_p^2 = .072$. Moreover, competition priming effects were indicated by a significant Group × Emotion × Muscle × Seconds interaction, $F(14, 658) = 3.1$, $p = .008$, $\eta_p^2 = .062$. To further analyze these effects, separate follow-up ANOVAs for the *Zygomaticus major* and the *Corrugator supercilii* were calculated.

Zygomaticus major

The 3(Emotion) × 8(Seconds) × 2(Group) ANOVA on the *Zygomaticus major* data revealed significant main effects of Emotion, $F(2, 46) = 5.4$, $p = .017$, $\eta_p^2 = .103$, Seconds, $F(7, 41) = 3.3$, $p = .024$, $\eta_p^2 = .065$, as well as an Emotion × Seconds interaction, $F(14, 34) = 2.6$, $p = .022$, $\eta_p^2 = .053$. Follow-up LSD tests ($p < .05$) for each second showed stronger *Zygomaticus major* responses to happy faces as compared to sad and neutral faces until the sixth second.

No interaction effects involving priming were found for *Zygomaticus major* (Group × Emotion, $F(2, 46) = 1.3$, $p = .28$, $\eta_p^2 = .026$; Group × Emotion × Seconds, $F(14, 658) = 1.1$, $p = .35$, $\eta_p^2 = .023$.

Corrugator supercilii

For the *Corrugator supercilii,* the 3(Emotion) × 8(Seconds) × 2(Group) ANOVA revealed significant main effects for Emotion, $F(2, 46) = 11.7$, $p = .001$, $\eta_p^2 = .199$, and Seconds, $F(7, 41) = 4.3$, $p = .006$, $\eta_p^2 = .084$. Further, marginally significant Emotion × Seconds, $F(14, 34) = 2.0$, $p = .057$, $\eta_p^2 = .042$, and Group × Emotion interactions, $F(2, 46) = 3.5$, $p = .058$, $\eta_p^2 = .070$, emerged as well as a significant Group × Emotion × Seconds interaction, $F(14, 658) = 2.5$, $p = .021$, $\eta_p^2 = .050$, the latter indicating priming effects.

To further investigate the priming effects on *Corrugator supercilii* activity, analyses were conducted separately for each of the three emotions. For happy expressions, a significant Group effect, $F(1, 47) = 3.9$, $p = .027$ (one-tailed), $\eta_p^2 = .077$, as well as a significant Group × Seconds interaction, $F(7, 329) = 4.6$, $p = .004$, $\eta_p^2 = .088$ (see Figure 2a) emerged. One-tailed t-tests

Table 1. *Impression Formation Task*

Item	Mean (SD) Competition ($n = 24$)	Mean (SD) Control ($n = 25$)	$F(1, 47)$	p
dislikable - likeable (unsympathisch – sympathisch)	0.79 (1.10)	1.48 (1.12)	4.69	.018
hostile - friendly (feindlich - freundlich)	0.63 (1.69)	1.52 (1.58)	4.62	.019
dismissive - cooperative (ablehnend - kooperativ)	– 0.08 (1.64)	0.88 (1.20)	5.54	.012
stubborn - amenable (eigensinnig - zugänglich)	– 0.62 (1.44)	0.76 (1.69)	9.50	.002

Note. Values recoded into – 3, – 2, – 1, 0, 1, 2, 3. p values one-tailed; original German item names in parentheses.

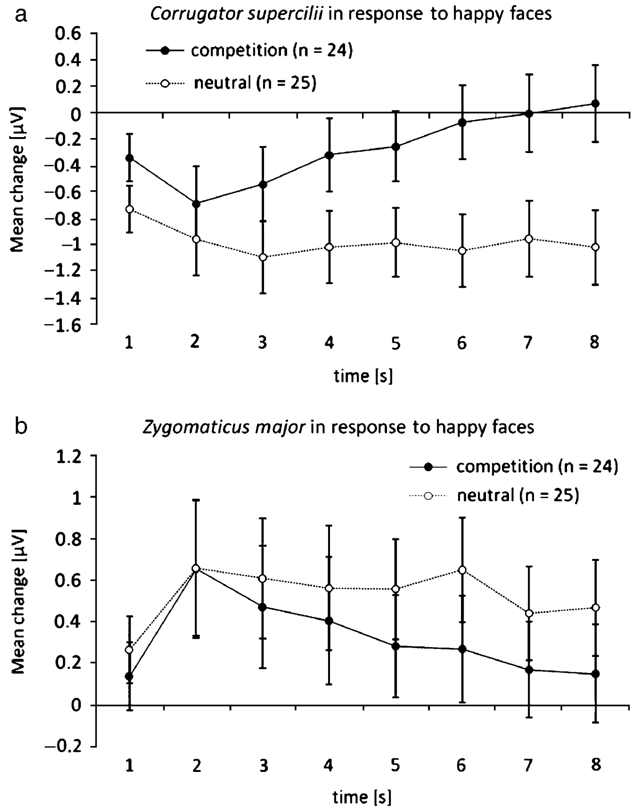

Figure 2. EMG activity change in µV (M ± SEM) for *Corrugator supercilii* (a) and *Zygomaticus major* (b) in response to happy avatar faces.

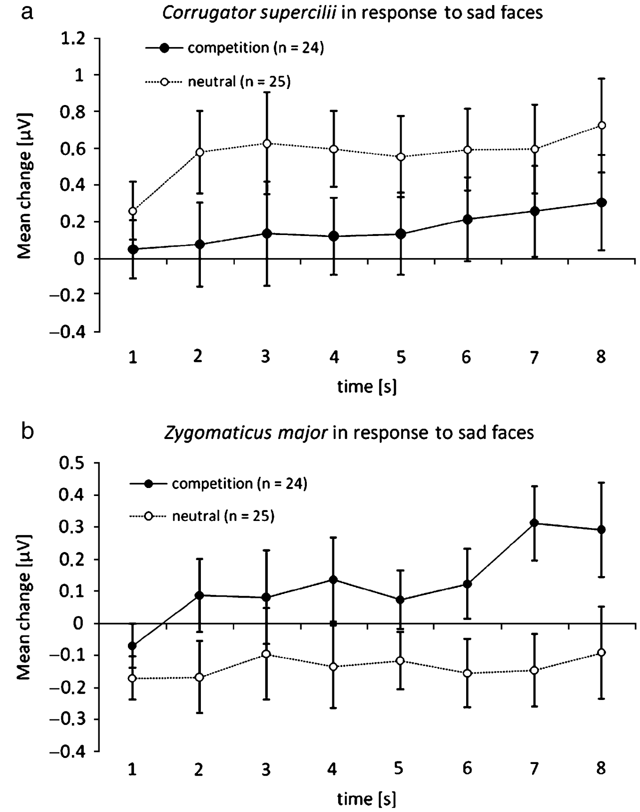

Figure 3. EMG activity change in µV (M ± SEM) for *Corrugator supercilii* (a) and *Zygomaticus major* (b) in response to sad avatar faces.

comparing the means for each second of picture presentation revealed significant group differences beginning at the fourth second (all $ts(47) > 1.8$, all $ps < .04$). Whereas with neutral priming *Corrugator supercilii* tension remained reduced during stimulus presentation, *Corrugator superciili* tension started rising again in the competition primed group beginning at the fourth second of stimulus presentation.

For *Corrugator supercilii* responses to sad faces, neither the Group effect, $F(1, 47) = 1.8$, $p = .186$, $\eta_p^2 = .037$, nor the Group × Seconds interaction, $F(7, 329) = 0.5$, $p = .665$, $\eta_p^2 = .011$, reached significance.

Separate LSD analyses ($p < .05$) within the two groups for stimulation congruent *Corrugator supercilii* reactions showed that for the neutrally primed group muscular activity was stronger to sad as compared to neutral faces except for the first and seventh second, whereas there were no significant differences in the competition primed group. Comparing reactions to happy and neutral faces, LSD analyses showed significantly less *Corrugator supercilii* activity in response to happy faces for both groups until the sixth second, but for the seventh and eighth second only for the neutrally primed group.

Discussion

The manipulation check revealed counter empathic effects in an impression formation task demonstrating the successful activation of competitive tendencies. As indicated by the awareness check, this activation occurred outside of conscious awareness.

The facial EMG data revealed two important issues. First, the significant congruent facial muscular reactions to avatars' emotional displays by the neutrally primed participants support the facial mimicry hypothesis for both happy and sad avatars' facial displays, and are in line with previous results (e.g., Dimberg et al., 2002). Viewing happy faces produced increased *Zygomaticus major* and decreased *Corrugator supercilii* activity, whereas viewing sad faces produced higher *Corrugator supercilii* activity.

Second, the subliminal activation of competition tendencies led to a different pattern of facial reactions. Specifically, whereas *Corrugator supercilii* activity in the control group decreased in response to happy faces—a reaction that is consistent with facial mimicry—competition priming significantly reduced this decrease. These results are the first to demonstrate that facial reactions to emotional facial expressions can be influenced by subliminally activated motivations. They are in line with Herrera, Bourgeois, and Hess (1998), who showed the influence of negative racial attitudes on facial reactions to ethnic out-group members, and are also in accordance with Lakin and Chartrand (2003), who used the same subliminal priming procedure as we did, but primed for need for affiliation and found intensified behavioral mimicry.

However, contrary to findings by Lanzetta and Englis (1989), in the present study facial muscular reactions were modulated in intensity by competition priming (*Corrugator supercilii* for happy faces) but did not turn to counter mimicry, even though the pattern of means for *Zygomaticus major* reactions to sad faces was consistent with such a reaction. This may be due to the fact that Lanzetta and Englis (1989) created an explicitly competitive gaming situation and also described both the participant and the

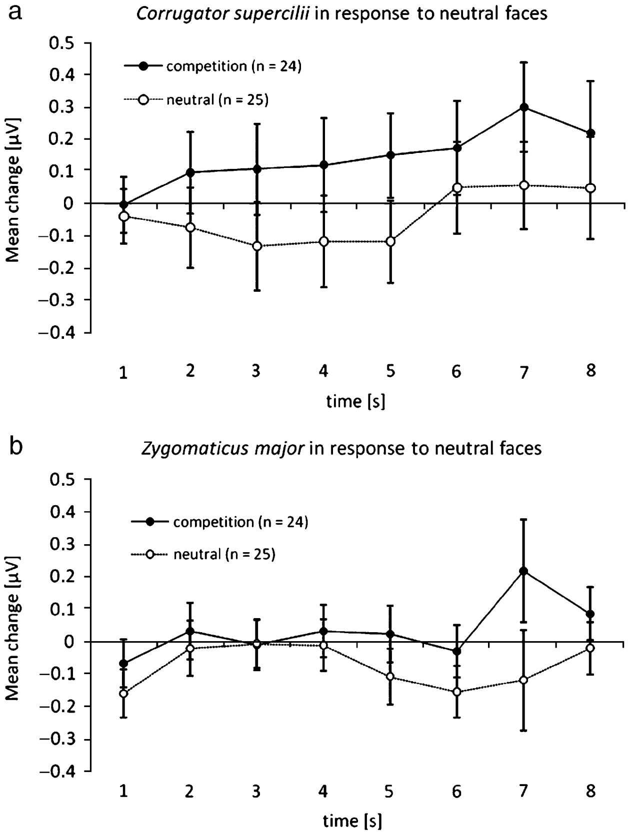

Figure 4. EMG activity change in µV (M ± SEM) for *Corrugator supercilii* (a) and *Zygomaticus major* (b) in response to neutral avatar faces.

opponent player as behaving in an uncooperative and competitive way. By contrast, in the present study participants were implicitly primed and then simply told to view the avatars' faces without being in an explicitly created competitive situation. An additional reason for the relatively weak effects, however, might be that we investigated women's facial reactions to emotional faces shown by women, and there is now converging evidence that women seem to be less competitively inclined than men (for a review, see Campbell, 2002). Thus, further experiments should investigate whether the competition priming has a stronger effect on men than the effect we found for women.

The competition priming was most effective in attenuating *Corrugator supercilii* reduction to happy faces. This makes sense since this muscle is very sensitive to valence and pleasantness (Lang, Greenwald, Bradley, & Hamm, 1993; Larsen, Norris, & Cacioppo, 2003). Specifically, the avatar's smile seems to signal that the upcoming competition might go badly for the observer thereby leading to increased *Corrugator supercilii* activity (see Figure 2) instead of further relaxation.

The lack of significant priming effects on the *Zygomaticus major* activity in response to happy faces may be due to the fact that, if a competition motive is activated, one may still "smile" toward a happy concurrent. This smile, however, may not necessarily signal enjoyment but instead could be a way to mislead the opponent about one's own thoughts and feelings ("I am still ok"). Nevertheless, a less positive emotional reaction to the opponent's happy emotional display is indicated by the *Corrugator supercilii* activity together with the less positive ratings in the impression formation task.

Reactions to sad faces (see Figure 3) did not show any significant differences between the two groups, even though an inspection of the means suggests less intense *Corrugator supercilii* reactions and even counter mimicry in the form of increasing *Zygomaticus major* activity in the competition primed group. There might be several reasons for the insignificant results. One reason might be that our cell sizes did not provide enough statistical power. Another reason might be that sad faces, unlike the grimace used by Lanzetta and Englis (1989), also have an appeal function which may have competed with the priming induced competition motive.

Interestingly, priming effects seem to become stronger during trials, as is especially obvious for *Corrugator supercilii* reactions to happy avatar expressions (see Figure 2a). One may therefore argue that facial mimicry is a strong reflex-like reaction that is difficult to overcome. In fact, findings by Dimberg et al. (2002) suggest that this may be the case. Subsequent facial responses may then mirror the contextual conditions of the subliminally primed competitive situation, namely the appraisal of the situation with regard to one's intentions (win) and prior information about the context (competition, rival, opponent). Thus, reduced congruent facial reactions may be explained by an overlay of the participants' evaluation of the presented emotional expressions of the avatars in relation to their own goals and interests.

It is furthermore interesting that reactions to the avatars were comparable to those one would expect to "real" stimulus persons. It seems that the avatars were socially perceived as opponents by the competition primed participants: Two of the four prime words yielded to perceiving the avatars as *opponents* and *rivals*—as individuals. Yet, the neutrally primed participants were not exposed to words containing such social information, and their data revealed mimicry reactions to happy as well as sad avatar facial expressions. This shows again, as documented by Bailenson and Yee (2005), that a virtual character is "treated" like a real person even though participants were neither instructed to interact in any way with the avatars nor to pay attention to the expressed emotions.

One could argue that our priming effects are mediated by some kind of mood induced by the experimental manipulation because the words we used for competition priming might have induced a negative mood state. This argument could apply to the results of the impression formation task and to the muscular responses to happy faces. For the former, one could argue that negative mood leads to a more negative evaluation of the stimulus person (cf. Schwarz, 1990). For the latter, one could argue that the happy faces are incompatible with the participants' negative mood and therefore are processed with lower intensity leading to less intense muscular reactions (cf. Niedenthal, Halberstadt, Margolin, & Innes-Ker, 2000). However, the mood explanation seems unlikely for the muscular responses to sad faces. Specifically, *Corrugator supercilii* activity in that condition showed hardly any change as a function of priming. The mood congruency hypothesis (for a review, see Blaney, 1986) and also the results by Niedenthal et al. (2000) would instead predict an increase in *Corrugator supercilii* activity. However, further research should assess the effects of competition priming on mood.

Although we used stimuli with social information for competition priming, the words used for neutral priming did not contain such information. Thus, one may ask whether similar results would be obtained if the neutral priming contained words like person, individual, human, etc. Yet, words like these do not transmit specific information about the person or about motives, goals, or even a situation. Hence, we assume that doing so would not affect results. However, the question of whether competition vs. noncompetition priming yielded the reported effects rather than some social vs. nonsocial priming may be relevant for future research. Importantly, however, this alternative explanation would still maintain that unconsciously primed goals affected facial mimicry.

In the present study, we presented happy and sad faces. It would be pertinent in future investigations to also consider other facial expressions that are closely related to dominance and competitiveness, such as pride or anger. For these expressions we predict the opposite pattern of results, namely that a competitive situation leads to increased mimicry—perhaps in a process that might be equivalent to the tit-for-tat status negotiations observed in nonhuman species (cf. Axelrod, 1984). That is, one could easily envision that being primed for competition might lead many individuals to mirror others' expressions of anger and pride in the service of being competitive and not subordinating one's own interests to those of the other.

Yet another question is whether the priming we used induces facial muscular reactions that are specific with respect to human or humanlike emotional faces. So it would be interesting whether one would find similar effects when participants are confronted with facial expressions, for example, from monsters. Also, it should be investigated in further experiments whether facial reactions to stimuli that do not hold facial expressions, like spiders and puppies, and to stimuli without any faces but with different emotional valence (like pictures from the International Affective Picture System; Lang, Bradley, & Cuthbert, 2005) are modulated as well.

In sum, the present research provides evidence for the automaticity of mimicking facial displays, but also for the notion that facial mimicry can be modified by subliminally activated goals and motives that remain outside the conscious awareness of the participant. Together with the results by Lanzetta and Englis (1989), there is now evidence that explicitly as well as implicitly activated goals and motives lead to comparable effects in facial muscular reactions to facial expressions, thus supporting the assumption that the same goal relevant perception processes and goal attainment related behavior will occur independent of the awareness of that goal (Chartrand & Bargh, 1996; Bargh et al., 2001).

REFERENCES

Atkinson, A., & Adolphs, R. (2005). Visual emotion perception: Mechanisms and processes. In L. Feldman-Barret, P. M. Niedenthal, & P. Winkielman (Eds.), *Emotion and consciousness* (pp. 150–184). New York: Guilford Press.

Axelrod, R. (1984). *The evolution of cooperation*. New York: Basic Books.

Bailenson, J. N., & Yee, N. (2005). Digital chameleons: Automatic assimilation of nonverbal gestures in immersive virtual environments. *Psychological Science*, *16*, 814–819.

Bargh, J. A. (1990). Auto-motives: Preconscious determinants of social interaction. In E. T. Higgins & R. Sorrentino (Eds.), *Handbook of motivation and cognition* (pp. 93–130). New York: Guilford Press.

Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle. A practical guide to priming and automaticity research. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 253–285). New York: Cambridge University Press.

Bargh, J. A., Gollwitzer, P. M., Lee-Chai, A., Barndollar, K., & Trötschel, R. (2001). The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of Personality and Social Psychology*, *81*, 1014–1027.

Blairy, S., Herrera, P., & Hess, U. (1999). Mimicry and the judgment of emotional facial expressions. *Journal of Nonverbal Behavior*, *23*, 5–41.

Blaney, P. H. (1986). Affect and memory: A review. *Psychological Bulletin*, *99*, 229–246.

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry*, *13*, 103–124.

Bourgeois, P., & Hess, U. (2008). The impact of social context on mimicry. *Biological Psychology*, *77*, 343–352.

Cacioppo, J. T., Priester, J. R., & Berntson, G. G. (1993). Rudimentary determinants of attitudes. II: Arm flexion and extension have differential effects on attitudes. *Journal of Personality and Social Psychology*, *65*, 5–17.

Campbell, A. (2002). *A mind of her own: The evolutionary psychology of women*. Oxford: Oxford University Press.

Chartrand, T . L., & Bargh, J. A. (1996). Automatic activation of impression formation and memorization goals: Nonconscious goal priming reproduces effects of explicit task instructions. *Journal of Personality and Social Psychology*, *71*, 464–478.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior-link and social interaction. *Journal of Personality and Social Psychology*, *76*, 893–910.

Chartrand, T. L., Maddux, W. M., & Lakin, J. L. (2005). Beyond the perception-behavior link: The ubiquitous utility and motivational moderators of nonconscious mimicry. In R. R. Hassin, J. S. Uleman, & J. A. Bargh (Eds.), *The new unconscious: Oxford series in social cognition and social neuroscience* (pp. 334–361). New York: Oxford University Press.

DeCoster, J., & Claypool, H. M. (2004). A meta-analysis of priming effects on impression formation supporting a general model of informational biases. *Personality and Social Psychology Review*, *8*, 2–27.

Dimberg, U. (1982). Facial reactions to facial expressions. *Psychophysiology*, *19*, 643–647.

Dimberg, U. (1990). Facial electromyography and emotional responses. *Psychophysiology*, *27*, 481–494.

Dimberg, U., & Lundquist, L. O. (1990). Gender differences in facial reactions to facial expressions. *Biological Psychology*, *30*, 151–159.

Dimberg, U., & Thunberg, M. (1998). Rapid facial reactions to different emotionally relevant stimuli. *Scandinavian Journal of Psychology*, *39*, 39–45.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science*, *11*, 86–89.

Dimberg, U., Thunberg, M., & Grunedal, S. (2002). Facial reactions to emotional stimuli: Automatically controlled emotional responses. *Cognition and Emotion*, *16*, 449–471.

Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect*. Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: Investigator's guide part I*. Palo Alto, CA: Consulting Psychologists Press.

Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for human electromyographic research. *Psychophysiology*, *23*, 567–589.

Gollwitzer, P. M., & Moskowitz, G. B. (1996). Goal effects on action and cognition. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 361–399). New York: Guilford Press.

Herrera, P., Bourgeois, P., & Hess, U. (1998). *Counter mimicry effects as a function of racial attitudes*. Poster presented at the 38th Annual Meeting of the Society for Psychophysiological Research, Denver, Colorado, USA.

Hess, U. (2001). The communication of emotion. In A. Kaszniak (Ed.), *Emotions, qualia, and consciousness* (pp. 397–409). Singapore: World Scientific Publishing.

Hess, U., & Blairy, S. (2001). Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on decoding accuracy. *International Journal of Psychophysiology*, *40*, 129–141.

Jäncke, L. (1993). Different facial EMG reactions of extraverts and introverts to pictures with positive, negative and neutral valence. *Journal of Personality and Individual Differences*, *14*, 113–118.

Jakobs, E., Fischer, A. H., & Manstead, A. S. R. (1997). Emotional experience as a function of social context: The role of the other. *Journal of Nonverbal Behavior*, *21*, 103–130.

Knutson, B. (1996). Facial expressions of emotion influence interpersonal trait inferences. *Journal of Nonverbal Behavior*, *20*, 165–182.

Krumhuber, E., & Kappas, A. (2005). Moving smiles: The role of dynamic components for the perception of the genuineness of smiles. *Journal of Nonverbal Behavior*, *29*, 3–24.

Lakin, J. L., & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science*, *14*, 334–339.

Lakin, J. L., Jefferis, V. E., Cheng, C. M., & Chartrand, T. L. (2003). The chameleon effect as social glue: Evidence for the evolutionary significance of nonconscious mimicry. *Journal of Nonverbal Behavior*, *27*, 145–161.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. F. (2005). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual. Technical Report A-6*. Gainesville: University of Florida.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, visceral, and behavioral reactions. *Psychophysiology*, *30*, 261–273.

Lanzetta, J. T., & Englis, B. G. (1989). Expectations of cooperation and competition and their effects on observers' vicarious emotional responses. *Journal of Personality and Social Psychology*, *56*, 543–554.

Larson, J. T., Norris, C. J., & Cacioppo, J. T. (2003). Effects of positive and negative affect on electromyographic activity over zygomaticus major and corrugator supercilii. *Psychophysiology*, *40*, 776–785.

Likowski, K. U., Mühlberger, A., Seibt, B., Pauli, P., & Weyers, P. (2008). Modulation of facial mimicry by attitudes. *Journal of Experimental Social Psychology*, *44*, 1065–1072.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). *The Karolinska Directed Emotional Faces* (KDEF) [CD-ROM]. Department of Clinical Neuroscience, Psychology section, Karolinska Institutet, Stockholm, Sweden.

Moser, E., Derntl, B., Robinson, S., Fink, B., Gur, R. C., & Grammer, K. (2007). Amygdala activation at 3T in response to human and avatar facial expressions of emotions. *Journal of Neuroscience Methods*, *161*, 126–133.

Niedenthal, P. M., Brauer, M., Halberstadt, J. B., & Innes-Ker, A. H. (2001). When did her smile drop? *Cognition and Emotion*, *15*, 853–864.

Niedenthal, P. M., Halberstadt, J. B., Margolin, J., & Innes-Ker, A. H. (2000). Emotional state and the detection of change in facial expression of emotion. *European Journal of Social Psychology*, *30*, 211–222.

Osgood, C., Suci, G., & Tannenbaum, P. (1957). *The measurement of meaning*. Urbana: University of Illinois Press.

Paulus, C. (2000). *Der Saarbrücker Persönlichkeitsfragebogen SPF (IRI)*. [*The Saarbrücker Personality Inventory SPF (IRI)*]. Web document [On-line]. Retrieved January 31, 2005 from http://www.uni saarland.de/fak5/ezw/abteil/motiv/paper/SPF(IRI).pdf

Ruch, W. (1999). Die revidierte Fassung des Eysenck Personality Questionnaire und die Konstruktion des deutschen EPQ-R bzw. EPQ-RK. [The revised version of the Eysenck Personality Questionnaire and the construction of the German EPQ-R resp. EPQ-RK]. *Zeitschrift für Differentielle und Diagnostische Psychologie*, *20*, 1–24.

Schwarz, N. (1990). Feelings as information: Informational and motivational functions of affective states. In R. M. Sorrentino & E. T. Higgins (Eds.), *Handbook of motivation and cognition: Foundations of social behavior* (pp. 527–561). New York: Guilford.

Sonnby-Borgström, M., Jönsson, P., & Svensson, O. (2003). Emotional empathy as related to mimicry reactions at different levels of information processing. *Journal of Nonverbal Behavior*, *27*, 3–23.

Spencer-Smith, J., Wild, H., Innes-Ker, A. H., Townsend, J., Duffy, C., Edwards, C., et al. (2001). Making faces: Creating three-dimensional parameterized models of facial expression. *Behavior Research Methods, Instruments, & Computers*, *33*, 115–123.

Wallbott, H. G. (1991). Recognition of emotion from facial expression via imitation? Some indirect evidence for an old theory. *British Journal of Social Psychology*, *30*, 207–219.

(Received October 20, 2007; Accepted June 3, 2008)