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Empathy, emotional contagion, and rapid facial reactions to angry and happy facial expressions

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Abstract: The aim was to explore whether emotional empathy is related to the capacity to react with rapid facial reactions to facial expressions of emotion, and if emotional empathy is related to the ability to experience a similar emotion as expressed by another person. People high or low in emotional empathy were exposed to pictures of happy and angry faces while their facial electromyography from the *zygomaticus major* and *corrugator supercilii* muscle regions was detected. High empathy participants rapidly reacted with larger zygomatic muscle activity to happy as compared with angry faces as early as after 500 ms after stimulus onset, and with larger corrugator muscle activity to angry than to happy faces after 500 ms. Accordingly, this group also reacted with a corresponding experience of emotion. The low empathy participants, in contrast, did not differentiate between the happy and angry stimuli with either facial muscles or in their self experience of emotion. The findings are related to the facial feedback hypothesis and the results are interpreted as support for the hypothesis that rapid and automatically evoked facial mimicry may be one important mechanism for emotional and empathic contagion to occur.

Keywords: emotion; emotional contagion; empathy; facial EMG reactions; facial expressions
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Empathy is one fundamental component in social life and emotional communication. There is no single definition of empathy (e.g. Levenson, 1996; Levenson & Ruef, 1992; for a review see Ickes, 1997). It has been proposed, for instance, that one aspect of empathy is the ability to accurately detect the emotional information transmitted by another person, as well as to be able to react emotionally to and/or to mimic the emotional expressions of other persons (e.g. Hatfield, Cacioppo, & Rapson, 1994; Levenson & Ruef, 1992; MacDonald, 2003). A further important aspect is the ability to experience the same emotion as another person, that is, to be able to catch and/or to share another person's emotional experience (e.g. Levenson & Ruef, 1992).

Converging evidence suggests that emotional communication has an evolutionary basis which includes a biological predisposition in both sender and receiver (Buck, 1984; Buck & Ginsburg, 1997; Darwin, 1872; Dimberg, 1988, 1997; Preston & de Waal, 2002). It is interesting to note that closely related species, such as chimpanzees, also share with humans the same facial muscles as well as many similar facial expressions (Gaspar, 2006; Gaspar & Esteves, 2011). The abilities for emotional communication and empathic reactions are developed early (e.g. Eisenberg, Murphy, & Shepard, 1997). For instance, newborn children may spontaneously start crying when they hear another child crying (Simner, 1971). It also seems to be an inherent tendency to imitate the facial actions displayed by another person. In support of this, it has been found that newborns can imitate different facial gestures as well as specific facial expressions (Field, Woodson, Greenberg, & Cohen, 1982; Meltzoff & Moore, 1977). Something akin to mimicking behavior has also been found in adults who are exposed to facial expressions (e.g. Dimberg, 1982, 1990; Lundquist & Dimberg, 1995). For instance, when subjects were exposed to pictures of happy and angry facial expressions they tended to spontaneously react with increased electromyographic (EMG) activity in the zygomatic muscle to happy faces and increased corrugator muscle activity to angry faces (e.g.

Dimberg, 1982). The zygomatic muscle elevates the cheeks to a smile, whereas the corrugator muscle wrinkles the eyebrows into a negative expression (e.g. Hjortsjö, 1970). Thus, people seem to spontaneously react by using the facial muscles that correspond to the facial stimuli.

According to the facial feedback hypothesis, the facial muscles function as a feedback system for a person's own experience of emotion (Adelmann & Zajonc, 1989; Buck, 1980; MacDonald, 2003; Meltzoff & Decety, 2003). One could therefore argue that the tendency to mimic another person's facial expression may be a key for empathy to occur (e.g. MacDonald, 2003; Meltzoff & Decety, 2003). That is, by reacting with a corresponding facial response to a sender's facial expression, the receivers get feedback from their facial muscles that will induce a similar emotion in themselves, which accordingly will culminate in empathy. In support of this hypothesis, it has been found that people can react both expressively and experientially when exposed to another person's emotional display (Dimberg, 1990; Lundquist & Dimberg, 1995; McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985; Vaughan & Lanzetta, 1980; for reviews see Hatfield et al., 1994 and Davis, 1994).

One could argue that if empathy is related to the capacity to react with facial reactions to the facial expressions of another person, then highly empathic people should be more reactive to facial expressions than should people who are low in empathy. Accordingly, Wiesenfeld, Whitman, and Malatesta (1984) found that highly empathic women were more likely to react with a corresponding facial reaction when they were exposed to videotaped excerpts of crying and smiling infants. Furthermore, cognitive aspects of empathy, such as the ability to take the perspective of others, have also been found to increase the probability of mimicking the mannerisms of another person (Chartrand & Bargh, 1999). Particularly interesting for the present study, it has also been found that people who are high as compared with low in emotional empathy tend to react more intensively with facial reactions to facial stimuli (Dimberg, Andréasson, & Thunberg, 2005, 2011; Sonnby-Borgström, 2002). When subjects were exposed to happy and angry faces it was found that only the High empathy group reacted with larger zygomatic activity to happy as compared with angry faces, and with larger corrugator activity to angry as compared with happy stimuli (e.g. Dimberg et al., 2005, 2011). The Low empathy group did not differentiate at all between the happy and angry stimuli (Dimberg et al., 2005).

To date, research has demonstrated that facial EMG reactions seem to mirror at least partly the face to which people are exposed (e.g. Dimberg, 1982; Lundquist & Dimberg, 1995), and these results may be taken as support for the hypothesis that motor mimicry is one mechanism behind emotional and empathic contagion (Bavelas, Black, Lemery, & Mullett, 1986; Hatfield et al., 1994; Lundquist & Dimberg, 1995). In most of the studies referred to earlier (e.g. Dimberg, 1990) the responses are based on data collected during longer stimulus intervals (5–8 s). Interestingly, however, it has also been found that distinct facial reactions can be evoked as early as after 400–500 ms of exposure to happy and angry facial stimuli (e.g. Dimberg, 1997; Dimberg & Thunberg, 1998; Dimberg, Thunberg, & Elmehed, 2000). Because of the rapidity of the facial reactions, and the fact that almost identical corresponding rapid reaction patterns were evoked during the first second of exposure even when the subjects were unconsciously exposed to happy and angry faces (Dimberg et al., 2000), these reaction patterns have been interpreted as being an effect of unconscious, automatically controlled processes (Dimberg et al., 2000; Dimberg, Thunberg, & Grunedal, 2002). This is consistent with the proposition that affective reactions in general can be evoked independently of conscious cognitive processes (e.g. Zajonc, 1980), and particularly that empathic reactions may be controlled, not only by conscious cognitive processes, but also by automatic unconsciously controlled processes (Bargh, Chen, & Burrows, 1996; Dimberg et al., 2000, 2002; Hodges & Wegner, 1997).

One aim of the present study was to explore whether emotional empathy is related to the capacity to react with a rapid facial reaction to the facial expression of another person. If so, people high in emotional empathy should be particularly reactive when exposed to facial expressions and consequently react with more intense and rapid facial reactions when exposed to, for instance, happy and angry faces. Consequently, people classified as High or Low in emotional empathy were exposed to pictures of happy and angry faces while their facial EMG activity was measured from the zygomatic and corrugator muscles. As in earlier studies (e.g. Dimberg, 1997) facial reactions were detected at 100-ms intervals during the first second after the stimulus onset.

A number of earlier studies (Dimberg, 1982; Dimberg et al., 2000, 2002; Dimberg & Lundquist, 1990; Dimberg & Thunberg, 1998) have shown that a sensitive and probably an optimal measure by which to detect a positive emotional response is to compare the zygomatic response to happy faces with the response to an angry control stimulus, that is, to express the response as the differential zygomatic response to happy versus angry faces. Similarly, it has been shown that a sensible measure by which to detect negative emotional responses is to compare the corrugator response to angry faces and the response to a happy control face, that is, to express the response as the differential corrugator response to angry versus happy faces. Consequently, in the present study it was predicted that the High as compared with the Low empathy group should react with a more intensive and rapid zygomatic response to happy as compared with angry stimuli, as well as a more intense and rapid corrugator response to angry as compared with happy faces. Because earlier studies (e.g. Dimberg, 1997) have demonstrated that different reaction patterns can be detected as early as 500–1,000 ms after stimulus onset, clear-cut differences in response to the stimuli were expected to appear during this stimulus period.

As noted above, it has been found that people can react both expressively and experientially when exposed to another person's emotional display (e.g. Dimberg, 1988, 1990; Lundquist & Dimberg, 1995). Furthermore, it has also been proposed that one important aspect in empathy is the ability to experience the same emotion as does another person, that is, to be able to catch and/or to share another person's experience of emotion (e.g. Levenson & Ruef, 1992). A second aim of the present study was therefore to explore whether people high in emotional empathy are more susceptible to empathic contagion than are people low in emotional empathy. Accordingly, it was predicted that the High empathic group would experience more happiness when exposed to happy as compared with angry faces, as well as more anger when exposed to angry as compared with happy faces. Because the Low empathy group was not expected to be susceptible to empathic contagion it was predicted that this group would not differ in emotional experience during exposure to happy and angry facial expressions.

Method

Participants

The participants were 96 students who were attending basic courses at Uppsala University, Sweden. Their mean age was 22.4 years ($SD = 3.02$ years). The subjects were paid with a cinema ticket that had a value of approximately US$10.00.

Questionnaire

To measure emotional empathy, a Swedish translation of the Questionnaire Measure of Emotional Empathy (QMEE) developed by Mehrabian and Epstein (1972) was used. The QMEE involves 33 items to which the respondents answer each item on a scale from "strong disagreement" (–4) to "strong agreement" (+4). The items are not specifically related to how people experience and/or react to facial expressions of emotion. Thus, any effects in facial reactions to facial expressions in the present study cannot be considered as dependent on the selection criteria. In order to evaluate the Swedish translation of the questionnaire, it was distributed to approximately 900 students at Uppsala University. It was found that the internal-consistency reliability for the Swedish version was fairly good, as indicated by Cronbach's $\alpha = 0.773$. In parallel to the American original QMEE (Mehrabian & Epstein, 1972), females scored higher as compared with males, $X_{females} = 56.52$ ($SD = 21.09$) and $X_{males} = 32.98$ ($SD = 22.96$). In order to get information about the test–retest reliability the questionnaire was distributed to 84 subjects who retested after 1.0–1.5 years. The test–retest reliability was also fairly good, as indicated by the correlation coefficient, $r = 0.771$.

The subjects in the present study were selected from a larger group which completed the Swedish translation of the questionnaire. As mentioned above, females generally rate themselves higher on the QMEE than do males (Mehrabian & Epstein, 1972). According to Davis (1994) this difference could be explained as an effect of different gender roles, which according to Eisenberg and Lennon (1983) becomes particularly apparent in self-report scales. This implies that if, for instance, only the highest scoring individuals are selected, the majority of them would be female. Therefore, to avoid this confounding problem with gender, male and female participants were separately selected into the respective High and Low empathy groups. Consequently, the 24 highest and lowest scoring male and female subjects were respectively selected into a High ($X = 67.08$, $SD = 14.73$) and a Low ($X = 11.96$, $SD = 16.54$) group.

Stimuli and procedure

Following a standard procedure (e.g. Dimberg, 1990) the subjects were individually tested while seated in a comfortable chair in a sound-attenuated laboratory room. They were exposed to slides of facial expressions projected onto a screen positioned approximately 1.5 m in front of them, with a picture size of 25 × 35 cm. Twelve slides each of happy and angry faces were selected from Ekman and Friesen's *Pictures of Facial Affect* (1976). Following the procedure from earlier studies (e.g. Dimberg, 1990) each participant was exposed to six consecutive presentations of one slide of an angry face and one slide of a happy face. Different subjects were exposed to different combinations of the pictures and the order of the angry and happy faces was counterbalanced across the participants. However, note that even if different participants saw different combinations of the angry and happy faces, the High and Low empathy groups were exposed to the same facial stimuli overall. The intertrial intervals ranged between 25 s and 35 s and were controlled using Contact Precision Instruments (CPI) hardware and software.

Following a standardized instruction procedure (e.g. Dimberg, 1990; Dimberg et al., 2011; Dimberg & Thunberg, 2007), the participants were told that their physiological activity was going to be measured while they were exposed to slides of different faces. In order to conceal the fact that their facial muscle activity was being measured, a cover story was used. The participants were told that the sweat gland activity in their faces was being measured. When interviewed after the experiment, none of the participants reported that they were aware that their facial muscle activity had been measured. After the interview, the participants were told the true purpose of the experiment.

Apparatus and data scoring

The facial EMG activity was measured following a standard procedure (e.g. Dimberg et al., 2002). That is, Ag/AgCl miniature electrodes were filled with electrode paste and were bipolarly attached to the left and right zygomatic and corrugator muscle regions (Fridlund & Cacioppo, 1986). To reduce the electrode site impedance the skin was cleaned with alcohol and rubbed with electrode paste. The raw EMG signals were measured using CPI amplifiers, band pass filtered from 10 Hz to 1,000 Hz, and were further analyzed using contour-following integrators with a time constant of 20 ms. The integrated signals were digitized using a 12-bit analogue-to-digital converter. This signal was stored on a personal computer with a sampling frequency of 100 Hz. The facial EMG data were scored and averaged in 100-ms intervals during the first second after stimulus onset. The facial reactions were expressed as the change in activity in microvolts from the prestimulus level, which was defined as the mean activity during the last second before stimulus onset.

Self experience of emotion

The subjects' self experience of emotion was measured using an abbreviated Swedish version of the Differential Emotion Scale (DES; Izard, Dougherty, Bloxom, & Kotsch, 1974).

As in earlier studies (e.g. Lundquist & Dimberg, 1995), the subjects were required to rate their own experience of emotion immediately after each series of six exposures to the respective happy and angry faces. Ratings were performed for the experience of happiness, anger, surprise, and fear, where each emotion was represented by three items (Izard et al., 1974). The rating scales ranged from 0 (not at all) to 10 (very much). To mask the purpose of the DES questionnaire the subjects were told that, because different subjects participate at different times of the day, they may also differ in for instance tiredness and mood. According to a standard control procedure they were therefore told to rate their mood on different scales (e.g. Lundquist & Dimberg, 1995) which, in addition to the abovementioned scales, also included if they felt tired and how interested they felt.

Design and statistical analysis

Before analysis, the facial EMG data were collapsed over the respective six trials and side of face. Separate ANOVAs were performed for each muscle region. Consequently, the basic design was two-factorial with Group (High vs. Low in empathy) as the between-subjects factor and Emotion (Angry vs. Happy face) as the repeated measure factors. Earlier studies have shown that the corrugator muscle activity initially increases during the first 100-ms intervals, and that this response does not differentiate between the emotional content of the stimuli (e.g. Dimberg, 1997; Dimberg et al., 2000; Dimberg & Thunberg, 1998, 2007). This sudden response has been interpreted as reflecting an eye movement or a startle reaction (e.g. Dimberg et al., 2000). Furthermore, earlier studies have also shown that for both the corrugator and the zygomatic muscles the most clear-cut difference between the stimuli appears after 500 ms of exposure (e.g. Dimberg, 1997; Dimberg & Thunberg, 1998, 2007). Thus, similarly to these studies the muscle activity was separately analyzed in two periods (0–500 ms and 500–1,000 ms) and, as in earlier studies, the most clear-cut difference between the stimuli and the groups was expected to appear during the second period.

To specifically compare the responses between happy and angry faces within all the respective intervals, Bonferroni's *t*-test was used, which is a procedure that consists of splitting up the level of significance among a set of planned comparisons. Consequently, this test does not require a prior significant overall F ratio (Kirk, 1968). To protect against the positively biased tests that are likely in repeated measures F-tests, Geisser and Greenhouse conservative F-tests were used by reducing the degrees of freedom (e.g. Kirk, 1968). This implies that the degrees of freedom for treatments and error terms were 1 and n—1 for all the respective comparisons (Kirk, 1968).

The rating data were summed over the three items representing each emotion and were analyzed in separate ANOVAs with group as the between-subjects factor and emotion as the within-subjects factor. A priori t-tests were used to specifically compare differences in ratings between exposures to happy as compared with angry faces.

Results

Facial EMG

Zygomaticus major

The results for the *zygomaticus major* muscle are presented in Figure 1.

There were no overall effects during the first period (0–500 ms).

During the second period (500–1,000 ms), however, the zygomatic muscle activity overall increased as a function of Intervals, $F(1, 94) = 9.83$, $p < .01$, $MS_e = 14.11$. The Emotion factor, $F(1, 94) = 4.58$, $p < .05$, $MS_e = 635.36$, indicated that the zygomatic activity was overall larger for happy as compared with angry faces. However, as indicated by the Group × Emotion interaction and, as can be seen in Figure 1, $F(1, 94) = 5.13$, $p < .05$, $MS_e = 635.36$, it was only the High empathy group that reacted with larger zygomatic activity to happy as compared with angry faces.

Planned Bonferroni's t-tests ($p < .05$) revealed that the High empathy group differentiated between the happy and the angry faces as early as during the 400–500-ms interval, as well as during all the following intervals. The Low empathy group, however, did not differentiate between the happy and the angry faces in any of the intervals.

Corrugator supercilii

The results for the *corrugator supercilii* major are presented in Figure 2. As can be seen in that Figure, and consistent with a number of earlier studies (e.g. Dimberg, 1997), the initial response during the first period (0–500 ms) was a rapid increase followed by a decrease, $F(1, 94) = 49.86$, $MS_e = 43.38$, $p < .01$. As expected, this response pattern did not differ between stimuli or groups.

During the 500–1,000-ms period, angry as compared with happy faces evoked an overall larger corrugator response, $F(1, 94) = 9.31$, $MS_e = 119{,}70$, $p < .01$. However, as indicated by the Group × Emotion interaction, $F(1, 94) = 4.52$, $MS_e = 119{,}70$, $p < .05$, and as can be seen in Figure 2, it was only the High empathy group that reacted with larger corrugator activity to angry as compared with happy faces.

Planned Bonferroni's t-tests ($p < .05$) revealed that the High empathy group reacted with larger corrugator activity to angry as compared with happy faces as early as during the 300–400-ms interval, as well as during all the following intervals. The Low empathy group, however, did not differentiate between the angry and the happy faces in any of the intervals.

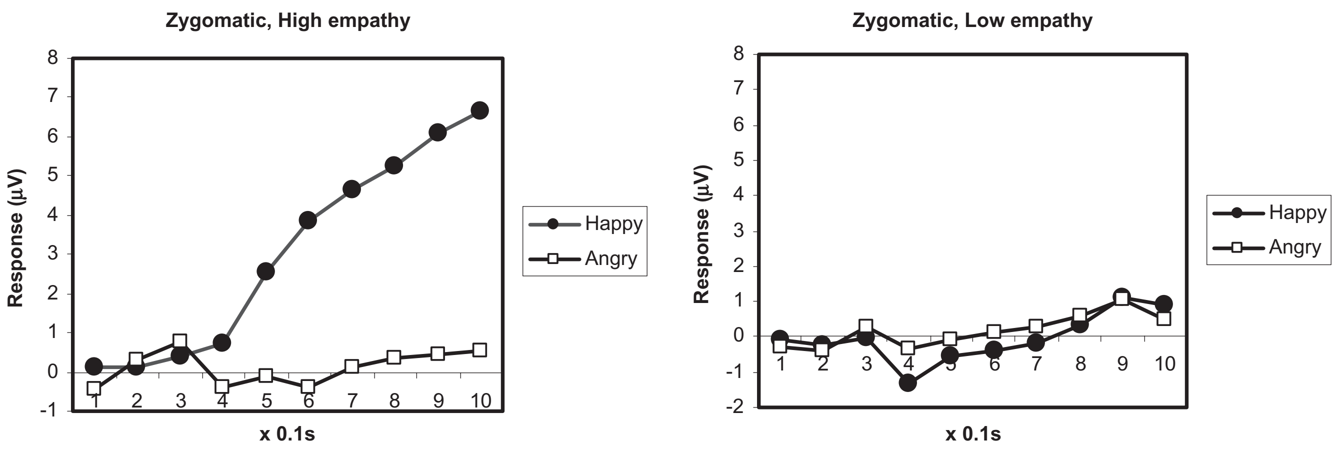

Figure 1. The *zygomaticus major* muscle response to pictures of happy and angry facial expressions for the High and Low empathy groups, plotted as a function of 100-ms intervals during the first second after stimulus onset.

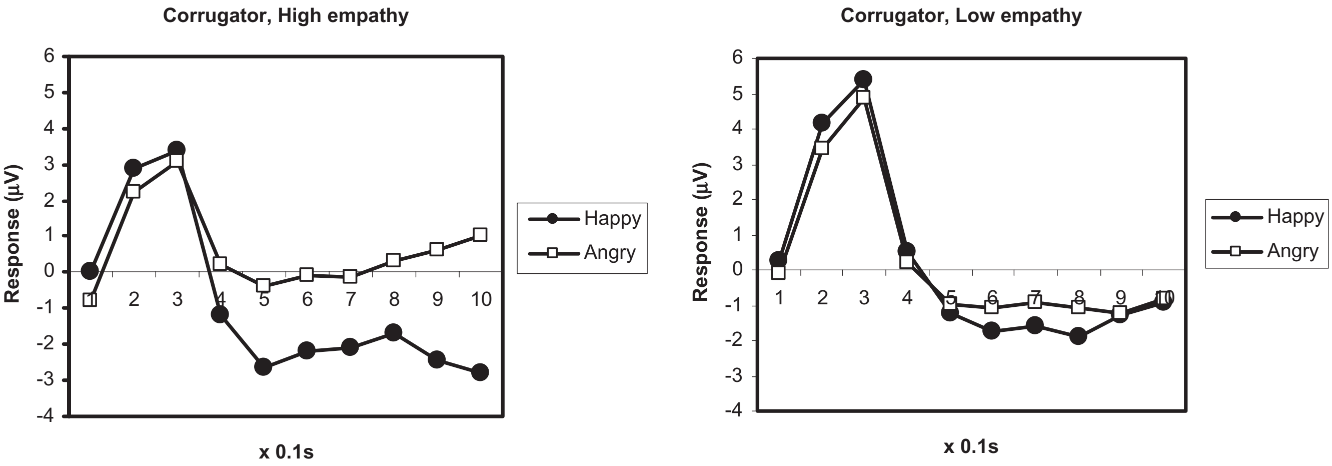

Figure 2. The *corrugator supercilii* muscle response to pictures of happy and angry facial expressions for the High and Low empathy groups, plotted as a function of 100-ms intervals during the first second after stimulus onset.

Table 1
Mean Ratings of Emotional Experience after Exposure to Angry and Happy Faces for the High and Low Empathy Groups

	High empathy group		Low empathy group	
	Angry faces	Happy faces	Angry faces	Happy faces
Anger	3.29*	1.79	2.06	1.85
Happiness	11.02*	12.69	13.06	13.73
Fear	3.56*	1.96	1.29	1.13
Surprise	6.02	6.10	6.67	6.42
Interest	16.56	16.27	17.69	17.13
Tiredness	5.06	4.75	4.65	4.56

*Significant difference between angry and happy conditions, $p < .05$.

The experience of emotion

The mean ratings for the different emotional scales are given in Table 1. The experience of anger was larger after exposure to angry as compared with happy faces, $F(1, 94) = 10.32$, $MS_e = 3.39$, $p < .05$. However, the Group × Emotion interaction indicated a difference in the response between the groups, $F(1, 94) = 5.90$, $MS_e = 3.39$, $p < .05$. As can be seen in Table 1 and according to the prediction, a priori *t*-tests revealed that it was only the High empathy group that reacted with more anger after exposure to angry as compared with happy faces, $t(94) = 3.99$, $p < .05$, whereas the Low empathy did not differentiate between the faces, $t < 1$.

Happy faces induced more happiness than did angry faces, $F(1, 94) = 12.88$, $MS_e = 5.07$, $p < .05$. As predicted, however, only the High empathy group reacted with more happiness after exposure to happy as compared with angry faces, $t(94) = 3.63$, $p < .05$, whereas the Low empathy group did not differentiate between the stimuli, $t < 1.5$.

Angry as compared with happy faces also induced more experience of fear, $F(1, 94) = 9.05$, $MS_e = 4.16$, $p < .05$. The High empathy group reacted with more fear as compared with the Low empathy group, $F(1, 94) = 8.15$, $MS_e = 14.19$, $p < .05$, whereas the significant Group × Emotion interaction indicated a difference between the groups, $F(1, 94) = 5.96$, $MS_e = 4.16$, $p < .05$. Follow-up *t*-tests revealed that it was only the High empathy group that reacted with more fear to angry as compared with happy faces, $t(94) = 3.86$, $p < .05$, whereas the Low empathy group did not, $t < 1$. There were no effects in experience of surprise, interest, or tiredness.

Discussion

Consistent with earlier studies (e.g. Dimberg, 1997; Dimberg & Thunberg, 1998) happy as compared with angry faces spontaneously and rapidly evoked larger zygomatic muscle activity, whereas angry as compared with happy faces also spontaneously and rapidly evoked larger corrugator muscle activity. Importantly, and as predicted, the High and Low empathy groups differed in this pattern of response. The High empathy group reacted with larger zygomatic activity to happy as compared with angry faces as early as after 400–500 ms of exposure, and with larger corrugator activity to angry as compared with happy faces after only 300–400 ms. The Low empathy group, in contrast, did not differ at all between the facial stimuli. Thus, these data clearly demonstrate that people who are high in emotional empathy have a capacity to react very rapidly to the emotional expressions of other persons, while people who are low in emotional empathy do not seem to react at all to the stimuli during the first second of exposure. These data are further consistent with earlier research indicating that highly empathic persons tend to respond with a corresponding facial expression when exposed to smiling faces (e.g. Wiesenfeld et al., 1984) and also that these persons, in contrast to less empathic persons, react with corresponding facial EMG reactions to both happy and angry facial expressions (e.g. Dimberg et al., 2005).

Interestingly, the present study demonstrates that the facial reactions displayed by the highly empathic group are evoked rapidly enough so that one could speculate whether these reactions are automatically controlled. That is, compared with previously obtained results (e.g. Dimberg, 1997; Dimberg & Thunberg, 1998), the facial EMG reactions look similar, both in shape and in rapidity, and in particular the patterns of response are almost identical to the responses elicited during the first second after stimulus onset, even when angry and happy faces are unconsciously exposed (Dimberg et al., 2000). One could therefore speculate whether this can be interpreted to mean that the responses detected in the present study are elicited by unconscious controlled processes. In this respect these results are consistent with the proposition that facial reactions are controlled by rapidly operating affect programs (Dimberg, 1997; Ekman, 1992; Tomkins, 1962) that can be triggered even without the involvement of conscious cognitive processes (Zajonc, 1980). One way to explicitly test this hypothesis would then be to select subjects who are high or low in emotional empathy and, as in an earlier study (Dimberg et al., 2000), use the backward-masking technique to expose them unconsciously to happy and angry faces while their facial EMG activity is detected.

It is not self-evident that the obtained effects should be interpreted solely in terms of mimicking behavior, which, as noted above, has been suggested to be one important mechanism for emotional contagion to occur (Hatfield et al., 1994; Lundquist & Dimberg, 1995). One component behind the evocation of facial reactions could also be that they initially are expressions of underlying emotional states. Even if it is difficult or perhaps impossible to make a pure distinction between these two interpretations, it is interesting that the self-ratings obtained in the present study can throw some light on this question. That is, congruent with larger zygomatic activity to happy faces in the highly empathic group, this group also experienced more happiness when exposed to happy as compared with angry faces, which could be interpreted as support for a mimicking/contagious effect, and perhaps also that one component of a reciprocating response was evoked. In parallel to this, and congruent with the larger corrugator muscle activity to angry as compared with happy faces in the High empathy group, angry faces evoked a larger experience of anger, supporting a mimicking/contagion interpretation. However, in addition, angry stimuli also evoked more experience of fear in the High empathy group, suggesting that the facial reaction may not solely reflect mimicking behavior, but also to a certain extent reflect an emotional reaction, such as fear. These findings are consistent with the results obtained in earlier studies (Dimberg, 1988; Lundquist & Dimberg, 1995) and further support the interpretation that both mimicry/contagion and emotional reactions can occur in a face-to-face situation. Thus, in parallel with those results, one could interpret the present data as at least partly reflecting mimicking behavior.

Note that, in the present study, as in a number of earlier studies (e.g. Dimberg, 1982, 1990, 1997), the critical effects are evaluated as differential activity to happy versus angry stimuli. Despite the fact that one could propose that this is a sensitive and probably an optimal measure by which to detect the different facial muscle reactions, one could perhaps further argue that the corrugator response to angry faces in the present study is certainly larger than that to happy faces after 500 ms, but the response is only slightly larger compared to the prestimulus level. From that point of view, these results would also be difficult to incorporate into a pure mimicking behavior perspective. However, note that the reason to evaluate the facial reactions in terms of the response in relation to a control stimulus with an emotional concomitant is that the corrugator reaction may reflect other underlying processes that are evoked to visual emotional stimuli in general. For instance, similar results have been obtained in earlier studies (e.g. Dimberg et al., 2000; Dimberg & Thunberg, 2007), in which it was argued that a preparatory activity was involved that obscured an increased activity compared with the prestimulus level, but did not obscure the fact that angry faces evoke a larger corrugator response than do happy faces. Furthermore, earlier studies have demonstrated that facial EMG reactions also reflect a component of an orienting response evoked to both angry and happy faces (Dimberg, 1996). Further indications that other processes may be involved in the elicitation of facial reactions in the present study are demonstrated by the fact that an initial corrugator response was elicited that peaked at 200–300 ms, and which was similar to the angry and happy faces for both groups. A similar response component has been detected in earlier studies (Dimberg, 1997; Dimberg et al., 2000; Dimberg &

Petterson, 2000; Dimberg & Thunberg, 1998) and probably reflects a startle reaction (Ekman, Friesen, & Simons, 1985) that does not differentiate between the emotional content of the stimuli, but rather reflects a nonspecific effect of the visual stimulation. Thus, the procedure by which to evaluate the effects by comparing the response to happy versus angry faces effectively controls for a number of nuisance and extraneous variables, and the use of a within-subjects design as regards the emotion factor, may further contribute to optimizing this evaluation procedure.

It is interesting to relate the present findings to the "facial feedback hypothesis." As noted above, this theory states that the facial muscle activity is essential for the emotional experience to occur (Buck, 1980). One could speculate as to whether the facial reactions detected in the present study are rapid enough to precede and therefore play an initiating role in inducing a self-experience of emotion (for a review of the initiating and modulating functions of facial feedback, see Adelmann & Zajonc, 1989). One interpretation of the present results could then be that the High empathy group, but not the Low empathy group, rapidly, automatically, and more intensively react with a corresponding facial reaction when exposed to the happy and angry faces. The feedback from these facial reactions will induce a similar emotion in the receiver, as manifested in a higher experience of the respective emotions and accordingly will culminate in empathy (Hatfield et al., 1994; MacDonald, 2003; Meltzoff & Decety, 2003). Thus, the highly empathic persons will directly and more intensively share the sender's experience of emotion, and consequently the present results support the prediction that people who are high in emotional empathy are more susceptible to empathic contagion than are people who are low in emotional empathy.

Surprisingly, the Low empathy group did not even tend to rapidly differentiate between the angry and happy faces in their facial muscle response. It is possible that the High empathy group reacted differently with their facial muscles to happy and angry faces because they were more accurate in perceiving the emotional displays. One question would then be whether the Low empathy group could discriminate at all between the stimuli. Data to answer this question was not collected in the present study. However, in a recently performed study (Dimberg et al., 2011), subjects who were high or low in emotional empathy were also required to rate the happy and angry faces to which they were exposed. The results clearly showed that the Low empathy group differentiated between the happy and angry faces in the same direction as did the High empathy group. Importantly, however, the results also revealed that the High empathy group showed a better empathic accuracy in the sense that they rated the happy faces as more intensive in happiness and the angry faces as more angry than did the Low empathy group. Thus, in light of the results in that study, it is difficult to explain the present results as an effect such that the Low empathy group could not discriminate between happy and angry faces.

As mentioned in the introduction, it has also been found that other aspects of empathy, such as the ability to take the perspective of others (Davis, 1983) are related to the intensity of mimicking other people's behavior (Chartrand & Bargh, 1999). One interesting question for future research would then be to relate dimensions of empathy such as perspective taking and empathic concern (Davis, 1983) to the ability to react with facial muscle reactions to the facial expressions of other persons.

Finally, it is interesting to note that neural models support the proposition that emotional stimuli can be processed both rapidly and automatically (LeDoux, 1989, 1995), and that this constitutes the basis for the ability to react rapidly to emotional stimuli. As noted above, the rapidly evoked facial reactions in the High empathy group can be interpreted as an outcome of automatic mimicking behavior. One could therefore speculate as to whether the elicitation of these reaction patterns is controlled by "mirror neurons," which consequently would provide an important neural mechanism by which human empathy could occur (e.g. Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Jackson, Meltzoff, & Decety, 2005; Leslie, Johnson-Frey, & Grafton, 2004).

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