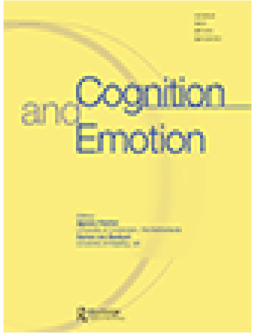

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Motor, affective and cognitive empathy in adolescence: Interrelations between facial electromyography and self-reported trait and state measures

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This study examined interrelations of trait and state empathy in an adolescent sample. Self-reported affective trait empathy and cognitive trait empathy were assessed during a home visit. During a test session at the university, motor empathy (facial electromyography), and self-reported affective and cognitive state empathy were assessed in response to empathy-inducing film clips portraying happiness and sadness. Adolescents who responded with stronger motor empathy consistently reported higher affective state empathy. Adolescents' motor empathy was also positively related to cognitive state empathy, either directly or indirectly via affective state empathy. Whereas trait empathy was consistently, but modestly, related to state empathy with sadness, for state empathy with happiness few trait–state associations were found. Together, the findings provide support for the notion that empathy is a multi-faceted phenomenon. Motor, affective and cognitive empathy seem to be related processes, each playing a different role in the ability to understand and share others' feelings.

Keywords: Trait empathy; State empathy; Motor mimicry; Facial EMG; Emotion.

Empathy-related responding is thought to play an important role in adolescents' prosocial behaviour and moral development (Eisenberg & Miller, 1987; Hoffman, 2000). Empathy is not a single ability, but a complex multi-dimensional construct, involving motor, affective and cognitive processes (Davis, 1996). The observation of another's emotional state may elicit motor empathy, which in turn may lead to affective and cognitive empathy (Hatfield, Rapson, & Cacioppo, 1994; Preston & De Waal, 2002). Motor empathy refers to the automatic mimicking of others' facial expressions, voices and gestures (e.g., Dimberg, 1990; Dimberg, Thunberg & Elmehed, 2000), but motor empathy may also comprise facial expressions induced by vicarious emotional experiences (Dimberg & Thunberg, 2012; Lundqvist & Dimberg, 1995). Positive emotions typically evoke an increase in

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activity of the zygomaticus major muscle (involved in smiling), and negative emotions typically evoke an increase in activity of the corrugator supercilii muscle (involved in frowning) (e.g., De Wied, Van Boxtel, Matthys, & Meeus, 2012; Larsen, Norris, & Cacioppo, 2003; Lundqvist & Dimberg, 1995). Affective empathy refers to the vicarious experience of emotions consistent with those of the observed person (Cohen & Strayer, 1996; Hoffman, 2000) and often results in sympathy, or empathic concern, which involves feelings of sorrow or concern for another and is an other-directed emotional response. Cognitive empathy, or perspective taking, can be defined as the ability to understand others' emotions (Davis, 1983). In addition to the distinction between affective, cognitive and motor processes, empathy can also be distinguished in terms of trait and state empathy. Trait empathy is the general ability to show empathy, whereas state empathy is the transient affective reaction elicited in concrete situations. Although these different empathy-related processes are assumed to be related to one another (Batson, 2009), there is a lack of empirical research studying these processes simultaneously.

We examined the interrelations of empathy-related processes in adolescence, which is generally seen as a formative period for empathy development. Although an important basis is established in childhood, several cognitive, relational and physical changes that take place during adolescence might affect the capacity or tendency to show empathy (Hoffman, 2000; Selman, 1980; Van der Graaff et al., 2013). Research on empathy in this age period has almost exclusively employed self-report measures of trait empathy, but it is unclear how these are related to the more objective state empathy measures. The current study aimed to investigate in a comprehensive manner the interrelations of adolescents' motor, affective and cognitive responses to empathy-eliciting film clips, and to test whether adolescents' reports of trait empathy are related to these state empathy-related responses.

INTERRELATIONS OF MOTOR, AFFECTIVE AND COGNITIVE STATE EMPATHY

Although motor, affective and cognitive state empathy are generally assumed to be interrelated, the underlying mechanisms are still a topic of debate. Several theorists have proposed motor empathy to underlie affective empathy, which in turn would facilitate cognitive empathy. Motor empathy is seen as a relatively automatic and rather non-cognitive process (Hoffman, 1984), resulting in emotional contagion, or the tendency to converge emotionally with others (Hatfield et al., 1994). According to the perception-action model of empathy (Preston & De Waal, 2002), observation of someone's emotional state leads to motor mimicry, and subsequently to an affective and cognitive empathic response. Similarly, the facial feedback hypothesis asserts that the facial muscle activity resulting from the automatic mimicking of others' emotional expressions induces corresponding emotions in the observer through a feedback process. In turn, this affective empathy should facilitate emotion understanding, and thus cognitive empathy (Hatfield et al., 1994; Hoffman, 1984; Lipps, 1907). Thus, from a theoretical perspective, the observation of emotional states can be expected to elicit motor empathy, and positive associations can be expected between motor, affective and cognitive state empathy. Moreover, affective empathy may mediate the association between motor empathy and cognitive state empathy.

Searching the literature, we found no studies that simultaneously investigated motor, cognitive and affective state empathy although the separate relations have been investigated in several studies. Positive but weak associations between motor empathy and affective state empathy were found when visual coding techniques were used to assess motor empathy (Anastassiou-Hadjicharalambous & Warden, 2007; Chisholm & Strayer, 1995; Eisenberg, Fabes, Miller, et al., 1989; Eisenberg et al., 1994; Zhou et al., 2002). However, when facial electromyography (EMG) was used to detect motor empathy, results were inconsistent and seemed dependent on the intensity of the emotional stimuli (Blairy, Herrera, & Hess, 1999; Hess & Blairy, 2001; Lundqvist & Dimberg, 1995). Further, the relation between motor and cognitive state empathy has only been examined for emotion recognition, which is just one aspect of cognitive empathy, and results are inconsistent (e.g., Hess & Blairy, 2001; Sato, Fujimura, Kochiyama, & Suzuki, 2013; Stel & Van Knippenberg, 2008). Thus, results of previous studies on the interrelations of motor, cognitive and affective state empathy are inconsistent and are difficult to interpret due to different methods to assess motor empathy (visual coding techniques vs. facial EMG) and the use of different kind of stimuli (empathy-eliciting film clips portraying emotions in a natural context vs. pictures of posed facial expressions). The fact that the studies that used film clips portraying emotions in true-to-life situations mainly used visual coding techniques (e.g., Eisenberg et al., 1994), whereas the studies that used pictures of posed emotional expressions mainly used facial EMG to assess motor empathy (e.g., Lundqvist & Dimberg, 1995), makes it even harder to integrate previous findings. A major limitation of the first category of studies is that visual coding techniques are a less reliable method to assess motor empathy than is facial EMG, with which also visually undetectable motor responses can be assessed (Van Boxtel, 2010). A drawback of the second category of studies is the use of posed emotional stimuli, which are less ecologically valid than are stimuli portraying natural emotions, and thus may constitute a weaker empathy-eliciting stimulus (McLellan, Johnston, Dalrymple-Alford, & Porter, 2010). Therefore, we aimed to extend the literature by investigating the interrelations of motor, affective and cognitive state empathy to empathy-eliciting film clips portraying natural expressions of happiness and sadness in true-to-life contexts, using the highly sensitive facial EMG technique to assess motor empathy.

ASSOCIATIONS BETWEEN TRAIT EMPATHY AND STATE EMPATHY

Besides the expected associations between empathy-related processes in a given situation, or the *state* empathy responses, it is a common assumption that people who have in general a higher tendency to empathise with others, and thus are higher in *trait* empathy, are also higher in *state empathy*. According to Davis' (1996) organisational model of empathy, individual differences in both affective and cognitive trait empathy influence the likelihood to engage in empathy-related processes in particular situations, and thus trait empathy should be positively related to state empathy.

However, as was the case for previous research on state empathy interrelations, the empirical literature with regard to associations between trait and state empathy is fragmented due to a lack of comprehensive studies and a use of different methodologies, and results are inconsistent. With regard to associations of trait empathy with motor empathy, respondents who reported higher affective trait empathy were found to show more pronounced facial EMG activity in response to pictures of posed facial emotion expressions (Dimberg & Thunberg, 2012; Sonnby-Borgström, 2002; Sonnby-Borgström, Jönsson, & Svensson, 2003) and in response to film clips of humans and animals in distressing situations (Westbury & Neumann, 2008), than respondents who reported lower affective trait empathy. However, when motor empathy was assessed with visual coding techniques, results on the association between affective trait empathy and motor empathy in response to empathy-inducing film clips were inconsistent (Eisenberg et al., 1988; Fabes, Eisenberg, Eisenbud, 1993). With regard to the relation between cognitive trait empathy and motor empathy, respondents who reported high cognitive trait empathy mimicked postures and movements of a confederate more often (Chartrand & Bargh, 1999), but did not show more motor empathy (measured with facial EMG) in response to film clips portraying emotional expressions (Achaibou, Pourtois, Schwartz, & Vuilleumier, 2008) than respondents reporting low cognitive trait empathy. However, the latter study used a measure to assess trait empathy, which not purely assesses cognitive empathy, but mixes it with affective trait empathy (Baron-Cohen & Wheelwright, 2004). Thus, the empirical literature is inconsistent with regard to the associations of affective and cognitive trait empathy with motor empathy, and the results appeared to vary by method.

Whereas there is a lack of studies on the associations between trait empathy and cognitive state empathy, several studies investigated the associations of affective or cognitive trait empathy with affective state empathy. Positive relations between affective trait empathy and affective state empathy were found in several studies (Batson, Bolen, Cross, & Neuringer-Benefiel, 1986; Eisenberg, Miller, et al., 1989; Eisenberg et al., 1988; Eisenberg et al., 1994; Westbury and Neumann, 2008; but see Eisenberg et al., 1991). Results on the association between cognitive trait empathy and affective state empathy are less clear. In one study, a positive association was found (Eisenberg et al., 1988), but in other studies the association was non-significant (Eisenberg et al., 1994), only significant for girls (Eisenberg, Miller, et al., 1989) or only significant in a condition in which respondents were explicitly instructed to imagine how the protagonist of an empathy evoking film clip felt and to concern oneself with the protagonist's feelings (Eisenberg et al., 1991). Thus, most of the research on the link between affective trait empathy and affective state empathy revealed positive relations, but for the relation between cognitive trait empathy and affective state empathy results are inconclusive.

Thus, as was the case for previous research on state empathy interrelations, the empirical literature on associations between trait and state empathy is fragmented due to a lack of comprehensive studies and the use of different methodologies. Despite the common assumption that people high in trait empathy are more likely to engage in empathy-related processes in particular situations, previous research revealed inconsistent results, especially with regard to cognitive trait empathy.

THE PRESENT STUDY

The current study extends past research on the relations between trait and state empathy by including assessments of affective and cognitive trait empathy as well as motor empathy, and affective and cognitive state empathy. Furthermore, we included assessments of state empathy in response to both happiness and sadness. Although previous empathy research has mainly focused on empathy with others' sadness or distress, empathy is not restricted to these emotions (Hoffman, 1982). Evidence from the limited available research including other emotions suggests that cognitive and affective empathic responses to one emotion are not equivalent to empathic responses to another emotion (e.g., Duan, 2000; Eisenberg et al., 2001; Zhou et al., 2002). Therefore, we examined the relationships separately for each emotion.

Although, due to our correlational design, we cannot address questions regarding causality, our comprehensive approach allowed us (1) to investigate whether motor, affective and cognitive state empathy indeed are interrelated, (2) to explore whether our data yield support for a model in which affective state empathy mediates the relation between motor empathy and cognitive empathy and (3) to investigate the relations of adolescents' trait empathy scores (affective and cognitive) to state empathy responses. Further, previous research in childhood suggests that the relations between measures of empathy-related responding may differ between boys and girls (e.g., Anastassiou-Hadjicharalambous & Warden, 2007; Eisenberg et al., 1988), but it is unclear whether this is the case in adolescence due to the lack of multi-method studies in this age group. Since previous research suggests that gender differences in empathy particularly emerge during adolescence (e.g., Van der Graaff et al., 2014), we used multi-group models to explore the associations for boys and girls separately, and to test for sex differences in the associations. We also tested for sex differences in levels of empathy across all measures.

METHOD

Participants

The present study used data from the on-going Research on Adolescent Development and Relationships (RADAR) project. Adolescents participating in RADAR were recruited from randomly selected schools in the province of Utrecht and four cities in The Netherlands. Participants of the current study were 379 adolescents who participated in a test session at the university and completed questionnaires during a home visit. Of the original 382 adolescents who participated in the test sessions, data of three participants were lost due to technical problems or experimenter error, and thus the sample consisted of 379 adolescents of which 212 boys (*M* age = 17.04 years, SD = .46, age range: 15.99–19.56 years) and 167 girls (*M* age = 16.94 years, SD = .41, age range: 15.68–18.29). The majority of the adolescents was native Dutch (95.8%), lived with both parents (78.4%), and came from families classified as medium or high socio-economic status (91.8%).

Procedure

Home visit

During a home visit, adolescents filled out a battery of questionnaires, among which a self-report measure on trait empathy. A trained research assistant provided verbal instructions in addition to written instructions that accompanied the questionnaires. Parents provided written informed consent before adolescents participated in the home visit. Adolescents received 30 Euros for their participation in the home visit.

Test session

Adolescents visited the university to participate in an individual test session during which self-reported and physiological responses to emotional film clips were assessed. Parents and adolescents both provided written informed consent before the session. The session took place in a testing room equipped with a personal computer and a 17-inch computer screen (HP 1730) to present the stimulus material and to record participants' self-reported responses to the film clips. An adjacent observation room with a one-way mirror, through which the experimenter could observe the participant, was equipped with a personal computer for control of the experiment and online monitoring of physiological data collection. This computer was connected to the computer in the testing room and to a portable digital recorder for the preprocessing and storage of physiological data (Vitaport III, TEMEC Instruments B.V., Kerkrade, The Netherlands), which was attached to the participant's chair. A trained female experimenter, who followed a written protocol detailing the verbal instructions and electrode placement, received the participant. After familiarising the participant with the procedure, electrodes were attached for the recording of EMG and electrocardiography (ECG). The participant was seated in a comfortable chair at a table facing the monitor of the stimulus computer (at approximately 90 cm distance). Participants were instructed to relax and watch a relaxation video (see below). Subsequently, the experimenter demonstrated the computerised empathy task using a mock film clip and gave instructions for completing ratings after each of six film clips (see below). The experimenter then dimmed the light and left the testing room after which the participant watched the film clips in randomised order and completed the questions after each film clip. EMG and ECG recordings (ECG results not being reported here) were continuously made throughout the task. Adolescents received 50 Euros for their participation in the test session.

Materials

Emotional film clips

During the test session, participants were exposed to empathy-inducing film clips, assembled from Dutch documentary films (De Wied et al., 2012).

Two film clips represented happiness (i.e., a girl passing her finals, and a boy winning a song contest), and two film clips represented sadness (i.e., a girl sent to a boarding school, and a boy who is rejected to join a select soccer team). The film clips, varying in length between 153 and 172 s, each started with a voice-over sketching the situation and ended with a target scene in which the central figure portrayed intense facial and vocal expressions of the target emotion. Facial EMG responses during these target scenes were analysed, varying in length between 35 and 56 s, as well as those during the first 10 s of the emotionally neutral opening scene following the voice-over, which served as baseline value (De Wied et al., 2012).

Relaxation video

Prior to the empathy task, participants viewed a 5-min fragment from an aquatic video (*Coral Sea Dreaming*, Small World Music, Inc.), which has been found to foster relaxation (Piferi, Kline, Younger, & Lawler, 2000). Prior to each film clip of the empathy task, participants also viewed a 1-min fragment from the same video to ensure recovery from emotional arousal induced by the previous film clip (different 1-min fragments of the aquatic video preceded different film clips).

Measures

Motor empathy

Bipolar EMG recordings were made from the left zygomaticus muscle and left corrugator muscle, using surface Ag/AgCl electrodes (contact area 2 mm) filled with conductive paste. Signals were antialiasing filtered using a 512 Hz low-pass filter and were digitised at 1024 Hz. Offline, a 20 Hz high-pass filter was used to remove movement artefacts from the data, and a 48–52 Hz band-reject filter was used to reduce influence of 50-Hz power line interference. Data were then visually inspected for remaining artefacts. In a small minority of participants, strong movement artefacts or 50-Hz interference appeared not to be completely removed which was resolved by additional filtering of the EMG signals. Mean EMG amplitude during the target scene of each film clip was expressed as a percentage of the mean amplitude during the baseline period because EMG amplitude is measured on a ratio scale. The resulting values were averaged across the two film clips associated with each emotion, resulting in a single value for zygomaticus and corrugator for each emotion.

Self-reported state empathy

A computerised procedure, adapted from Strayer's (1993) Empathy Continuum, was used to assess adolescents' affective and cognitive responses to the emotional film clips (De Wied, Goudena, & Matthys, 2005). After each film clip questions were asked about the quality and intensity of observed and experienced emotions. Based on participants' ratings, a score on affective state empathy and cognitive state empathy was composed (see below). The prominent emotion in each clip was identified by almost all participants in the current study (ranging from 98.4% to 100%). Thus, individual differences in motor, affective and cognitive responses to the film clips cannot be attributed to differences in emotion recognition.

Affective state empathy. Respondents identified the *quality* of the emotion expressed by the protagonist by marking through a mouse click one or more pictograms portraying: (1) fear, (2) anger, (3) happiness, (4) sadness, (5) surprise or (6) neutral/no emotion. Next, respondents identified the *quality* of their own experienced emotions using the same pictograms (except if they had chosen option 6). They were also asked to indicate the *intensity* of the emotion(s) they had experienced on a scale ranging from 1 ("a little") to 4 ("very much"). In the current study, affective state empathy responses refer to an exact match between observed and experienced emotions, scored on a 5-point scale (0 = no emotion, 4 = very much). Respondents received a zero score if they identified the target emotion incorrectly and/or did not experience the target emotion. If the target emotion was correctly identified *and* experienced by the respondent, they received a score between 1 and 4 depending on the intensity of their emotional experience (1 = a little, 4 = very much). Thus, our measure of *affective* state empathy also assesses a *cognitive* process (i.e., emotion recognition), since it is generally assumed that to experience mature empathy one needs to be aware that the experienced emotion is a response to another's emotion (e.g., Eisenberg, Shea, Carlo, & Knight, 1991; Hoffman, 2000). However, because 98.4–100% of the participants identified the emotions correctly, the variance in scores on this measure reflects differences in the extent to which participants experienced the portrayed emotions themselves.

Scores were averaged across the two film clips for each emotion. In response to the happiness clips, 62% of all respondents received a score higher than 0 on the affective state empathy scale. In response to the sadness clips 46.2% received a score higher than 0.

Cognitive state empathy. Following the questions on affective empathy, respondents were asked whether they felt happy or sorry (yes/no) for the protagonist. If they indicated "yes", they were asked to explain aloud why they sympathised. Cognitive attributions were collected after a sympathy (rather than affective empathy) rating because far more respondents report sympathy than empathy. In response to the happiness clips, 95% of all respondents reported that they felt happy for the protagonist. In response to the sadness clips 88.4% reported they felt sorry. Respondents' answers were recorded and coded by two trained coders.

In accordance to Strayer's (1993) Empathy Continuum, cognitive attributions were coded on an 8-point scale, based on developmental models of social cognition and empathy development (Hoffman, 1975; Hughes, Tingle, & Sawin, 1981). Respondents received a score 0 if they did not correctly identify the target emotion experienced by the protagonist. If participants identified the emotion correctly, but reported no sympathy (answer "no" to the question whether they felt happy/sorry for the protagonist) they received score 1. The presence of a sympathetic response, and a correct identification of the protagonist's emotion were necessary to get a score level 2 or higher on the cognitive state empathy scale: 2 = no or irrelevant attribution, 3 = attribution based on events only, 4 = minimal mention of the stimulus person in the event, 5 = attribution indicating association to own experience, 6 = attribution indicating responsiveness to character's internal state or general life situation, 7 = attribution indicating explicit role taking. Inter-scorer reliabilities (Cohen's kappa) between the two coders ranged from .65 to .88 (mean κ = .76) across the four film clips. Scores on cognitive state empathy were averaged across the two film clips for each emotion.

Self-reported trait empathy

During the home visit, adolescents reported on their own empathic disposition, using two subscales of the Dutch version of the Interpersonal Reactivity Index (IRI; Davis, 1983; Hawk et al., 2013): empathic concern, which taps affective aspects of empathy, and perspective taking, which taps cognitive aspects. Adolescents scored the items on a 5-point scale, ranging from 0 (*doesn't describe me at all*) to 4 (*describes me very well*). The Dutch version of the IRI has adequate internal consistency and validity (Hawk et al., 2013). The correlation between affective trait empathy and cognitive trait empathy was r = .52 (p < .001) in the current sample.

Affective trait empathy. The 7-item empathic concern subscale assessed adolescents' tendency to sympathise with others in need. A sample item of this subscale is "I often have tender, concerned feelings for people less fortunate than me". For the current sample Cronbach's alpha was .70.

Cognitive trait empathy. The 7-item perspective taking subscale assessed adolescents' tendency to consider others' viewpoints. A sample item of this subscale is "I try to look at everybody's side of a disagreement before I make a decision". For the current sample, Cronbach's alpha was .78.

Missing data

Across all measures on average 4.4% (ranging from 0% to 6.6%) was missing. Little's Missing Completely at Random test revealed a normed χ^2 (χ^2/df) value of 1.34 indicating that the data were likely missing at random and missing values could safely be imputed (Bollen, 1989). The Expected Maximisation algorithm in the Multiple Imputation module of LISREL9.1 was used to impute missing values. Imputed data of all 379 cases were used in further analyses.

Statistical analyses

Before answering our research questions, we checked whether the emotional film clips evoked the expected facial muscle responses, using one-sample *t*-tests (two-tailed) on changes in zygomaticus and corrugator EMG activity from baseline level during target scenes. Further, repeated measures analyses of variance (ANOVAs) were conducted on these changes for each muscle with Emotion (Sad vs. Happy) as the repeated measures factor. Subsequently, we tested for sex differences on self-reported and facial indices, using independent samples *t*-tests. Eta squared values (η^2) are reported as estimates of effect size, and can be classified as follows: no substantial ($\eta^2 < .02$), small ($.02 \leq \eta^2 < .13$), medium ($.13 \leq \eta^2 < .26$), or large ($\eta^2 \geq .26$) (see Cohen, 1988, pp. 413–414). To answer our first and second research questions, path analyses were conducted using MPlus version 7 (Muthén & Muthén, 1998/2012), in which we tested separately for happiness and sadness whether indices of state empathy (motor, affective and cognitive) were interrelated. With regard to our first research question, we tested in these models whether motor empathy (zygomaticus EMG activity for happiness, corrugator EMG activity for sadness) was predictive of self-reported affective and cognitive state empathy in response to the stimuli. With regard to our second research question, we tested whether affective state empathy mediated the relation between motor empathy and cognitive empathy. To answer our third research question, we also tested in these models whether adolescents' affective and cognitive trait empathy predicted motor empathy, and affective and cognitive state empathy.

In addition, a series of nested multiple group models was examined to test for sex differences on each regression path. If the results of a chi-square difference test indicated that constraining a parameter did not deteriorate the model fit significantly, the parameter was assumed to be equal for boys and girls (Kline, 2005). Models were estimated using a robust maximum likelihood estimation method (Satorra & Bentler, 2001).

RESULTS

Preliminary analyses

Validity checks

Figure 1 shows the facial EMG responses to the emotional film clips. To check whether the emotional film clips evoked the expected facial muscle response, one-sample *t*-tests on changes from baseline level during target scenes were conducted. Consistent with the literature (e.g., De Wied et al., 2012; Larsen et al., 2003), this revealed a significant increase in zygomaticus EMG activity, $t(378) = 14.36$, $p < .001$ and a significant decrease in corrugator EMG activity, $t(378) = -14.37$, $p < .001$, in response to film clips portraying happiness. Corrugator activity increased significantly in response to film clips portraying sadness, $t(378) = 14.46$, $p < .001$. Zygomaticus activity also showed a significant increase in response to sadness, $t(378) = 3.04$, $p < .01$, but this increase was much smaller than that in corrugator activity. Furthermore, results from repeated measures ANOVAs showed exposure to happiness to evoke significantly stronger zygomaticus EMG responses than sadness: $F_{\text{happiness vs sadness}}(1, 377) = 207.88$, $p < .001$, $\eta^2 = .36$. In contrast, corrugator EMG activity increased stronger during sadness than during happiness: $F_{\text{sadness vs happiness}}(1, 377) = 475.12$, $p < .001$, $\eta^2 = .56$. Thus, the stimuli on average evoked the expected facial muscle responses.

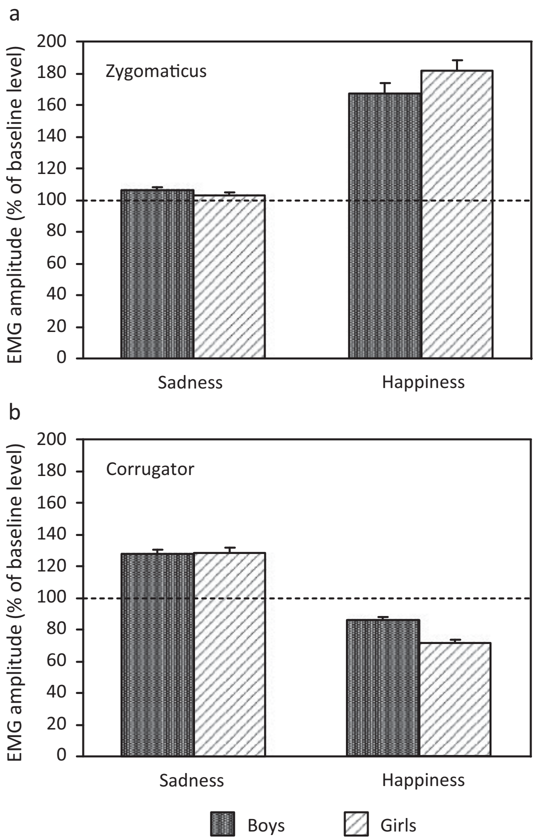

Figure 1. *Boys' and girls' mean level (+SE) of zygomaticus EMG activity (a) and corrugator EMG activity (b) for sadness and happiness.*

Sex differences in mean scores

Descriptive statistics for boys' and girls' facial EMG responses to the emotional film clips are presented in Table 1. Independent *t*-tests revealed for happiness no significant sex differences in mean zygomaticus EMG responses although boys decreased significantly less in corrugator EMG activity than girls. For film clips portraying sadness, there were no sex differences in corrugator or zygomaticus EMG activity.

Results in Table 1 show that girls reported significantly higher mean levels of affective state empathy than boys in response to happiness (η^2 = .05) and sadness (η^2 = .06). In addition, girls' cognitive state empathy in response to happiness (η^2 = .05), and sadness (η^2 = .04) was significantly

Table 1. *Mean scores for boys and girls on facial EMG and self-reported measures of empathy-related responding*

	Total (N = 379)		*Boys (n = 212)*		*Girls (n = 167)*		*Boys vs. girls*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*t*	η^2
State empathy								
Happiness								
Zygomaticus EMG	174.07	100.39	167.74	94.82	182.10	106.79	−1.39	.01
Corrugator EMG	79.91	27.22	86.24	27.27	71.88	25.01	5.28***	.07
Affective state empathy	1.15	.88	.98	.87	1.37	.85	−4.40***	.05
Cognitive state empathy	4.79	1.25	4.55	1.29	5.11	1.13	−4.42***	.05
Sadness								
Zygomaticus EMG	104.59	29.38	106.12	28.09	102.64	30.92	1.15	.00
Corrugator EMG	128.29	38.08	128.03	38.50	128.62	37.64	−.15	.00
Affective state empathy	.68	.74	.52	.70	.90	.73	−5.11***	.06
Cognitive state empathy	4.53	1.46	4.28	1.47	4.84	1.38	−3.79***	.04
Trait empathy								
Affective trait empathy	2.45	.56	2.24	.52	2.72	.50	−9.01***	.18
Cognitive trait empathy	2.22	.61	2.09	.57	2.38	.61	−4.86***	.06

***$p < .001$.

higher than boys' cognitive state empathy. Results in Table 1 also show that girls reported significantly higher levels of affective trait empathy (η^2 = .18) and significantly higher levels of cognitive trait empathy (η^2 = .06) than boys (Table 1).

Path analyses on interrelations of trait and state empathy-related measures

Happiness

Figure 2 shows the results of the final path model for happiness. Results of chi-square difference tests indicated that constraining across sex the estimates of the path between cognitive trait empathy and affective state empathy ($\Delta\chi^2$ (1) = 6.74, p < .01), and the path between motor empathy (zygomaticus EMG activity) and cognitive state empathy ($\Delta\chi^2$ (1) = 9.82, p < .01) worsened the model fit significantly. The fit of the final model in which these two paths were allowed to freely vary and all other paths were constrained to be equal across sex was good, χ^2 (7) = 2.78, p = .90, Root Mean Square Error of Approximation (RMSEA) = .00, Comparitive Fit Index (CFI) = 1.00. Boys' and girls' higher motor empathy (zygomaticus EMG activity) significantly predicted higher affective state empathy, and only for boys, higher motor empathy significantly predicted cognitive state empathy. For boys and girls, higher affective state empathy was significantly predictive for higher cognitive state empathy. Moreover, mediational analyses revealed a significant indirect effect of boys' and girls' motor empathy on cognitive state empathy, mediated by affective state empathy. Affective trait empathy and cognitive trait empathy were not significantly predictive for adolescents' motor empathy (zygomaticus EMG activity). However,

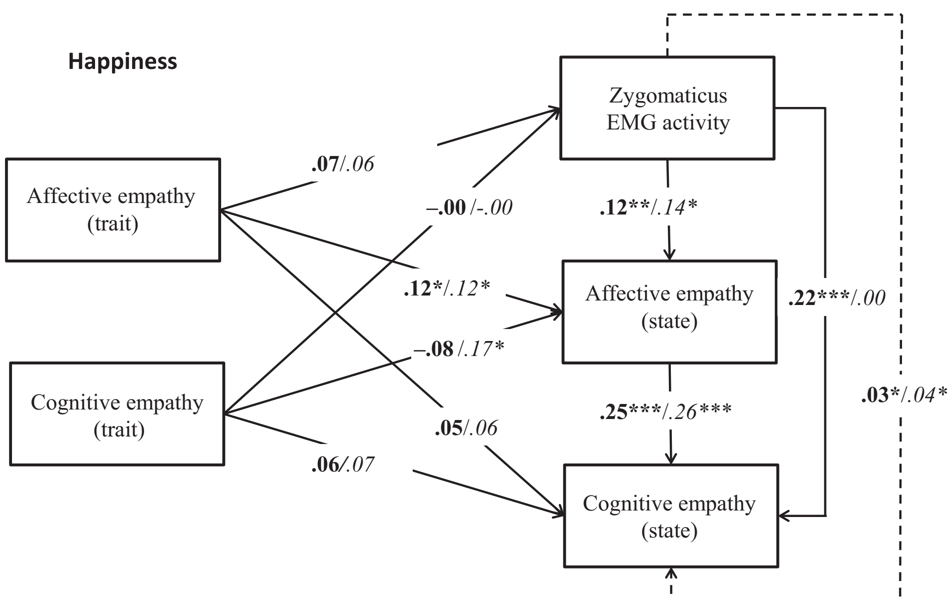

Figure 2. *Standardized estimates of boys' (printed bold) and girls' (printed in italics) relations between trait empathy (affective and cognitive) and state empathy (motor, affective, cognitive) in response to film clips portraying happiness. Only the path from cognitive trait empathy to affective state empathy, and the path from motor empathy (zygomaticus EMG activity) to cognitive state empathy were allowed to freely vary across sex. All other paths were constrained to be equal between boys and girls. The dashed line represents the indirect effect of motor empathy (zygomaticus EMG activity) on cognitive state empathy, mediated by affective state empathy.*
Note: *p < .05, **p < .01, ***p < .001.

higher affective trait empathy was significantly predictive for boys' and girls' higher affective state empathy. For girls, but not for boys, higher cognitive trait empathy significantly predicted higher affective state empathy. For both boys and girls, cognitive trait empathy was not significantly predictive for cognitive state empathy ($p > .05$).

Sadness

Figure 3 shows the results of the final path model for sadness. Results of chi-square difference tests indicated that constraining the estimates of the path between affective trait empathy and motor empathy (corrugator EMG activity) across sex worsened the model fit significantly, $\Delta\chi^2$ (1) = 8.21, $p < .01$. The fit of the final model in which this path was allowed to freely vary and all other paths were constrained to be equal across sex was good, χ^2 (8) = 5.85, $p = .66$, RMSEA = .00, CFI = 1.00. Boys' and girls' higher motor empathy (corrugator EMG activity) significantly predicted higher affective state empathy, and higher affective state empathy significantly predicted higher cognitive state empathy. Further, although adolescents' motor empathy could not directly predict cognitive state empathy, mediational analyses revealed a significant indirect effect of adolescents' motor empathy on cognitive state empathy, mediated by affective state empathy. In addition, boys' affective trait empathy was negatively predictive for their motor empathy (corrugator EMG activity), but for girls higher affective trait empathy was predictive for higher motor empathy. Furthermore, for both boys and girls, higher affective trait empathy was predictive for higher affective state empathy, but not significantly predictive for cognitive state empathy. For both groups, cognitive trait empathy was not significantly predictive for motor and affective state empathy, but significantly predicted higher cognitive state empathy.

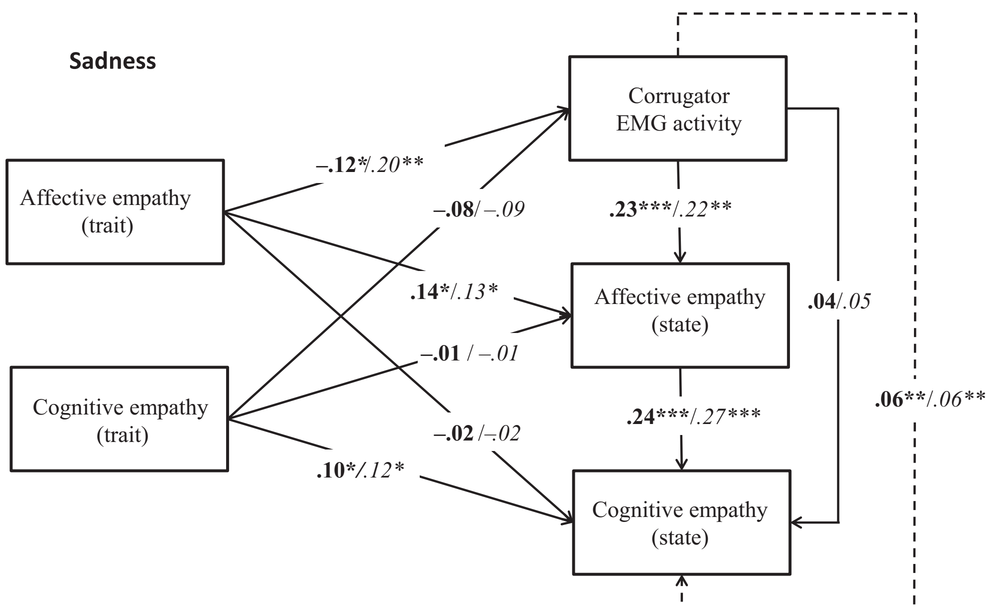

Figure 3. *Standardized estimates of boys' (printed bold) and girls' (printed in italics) relations between trait empathy (affective and cognitive) and state empathy (motor, affective, cognitive) in response to film clips portraying sadness. Only the path between affective trait empathy and motor empathy (corrugator EMG activity) was allowed to freely vary across sex. All other paths were constrained to be equal between boys and girls. The dashed line represents the indirect effect of motor empathy (corrugator EMG activity) on cognitive state empathy, mediated by affective state empathy.*

DISCUSSION

Using a multi-measure approach, the present study examined interrelations of state and trait measures of empathic functioning. Regarding state empathy, the study revealed that, for both happiness and sadness, adolescents who responded with stronger motor empathy consistently report higher affective state empathy, which supports the theoretical notion that motor and affective responses to others' emotional states are related (Hatfield et al., 1994; Preston & De Waal, 2002). Furthermore, in accordance with the facial feedback hypothesis (Hatfield et al., 1994; Hoffman, 1984; Lipps, 1907), motor empathy was positively related to cognitive state empathy, indirectly via affective state empathy. Positive relations between trait and state empathy were most consistently found for sadness. To our knowledge, this study is the first to include facial EMG measurement of motor empathy together with trait and state measures of both cognitive and affective empathy. The findings of consistent, but modest associations, provide support for the notion of empathy as a multi-faceted phenomenon.

Interrelations of state empathy measures

In line with our expectations, our findings revealed that motor empathy responses were consistently related to respondents' self-reported affective state empathy. Adolescents who showed stronger zygomaticus EMG activity in response to happiness and corrugator EMG activity in response to sadness, reported to have stronger experienced the observed emotion. Also, adolescents' motor empathy was positively related to cognitive state empathy, mediated by affective empathy. Although our correlational findings cannot confirm the theoretical assertion that motor empathy *induces* the experience of the corresponding emotion, which in turn *facilitates* cognitive empathy, our findings reveal that motor, affective and cognitive responses to observed emotions are positively related, in line with theories on emotional contagion (Hatfield et al., 1994; Hoffman, 1984; Lipps, 1907). The fact that previous studies found no significant relation between motor empathy and emotion recognition (Blairy et al., 1999; Hess & Blairy, 2001) may be explained by two important methodological differences between our study and those previous studies. First, our measure of cognitive empathy not only concerned emotion recognition, but also cognitive attributions. Second, in the current study we used stimuli that portrayed natural emotions in true-to-life situations, whereas the previous studies used posed facial expressions (Blairy et al., 1999) or used an emotional imagery task (Hess & Blairy, 2001). Thus, our findings suggest that in response to natural emotions, motor empathy is modestly but significantly positively related to affective state empathy and indirectly to cognitive state empathy.

Associations between trait empathy and state empathy

In line with Davis' (1996) organisational model of empathy, which suggests individual differences in trait empathy to affect the likelihood to engage in empathy-related processes in particular situations, we expected adolescents' trait empathy to be positively related to their motor, affective and cognitive state empathy responses. With regard to motor empathy, we did not find strong evidence to support this notion. Only for girls, affective trait empathy was positively related to motor empathy in response to sadness. Remarkably, for boys, a negative relationship was found. Affective trait empathy and cognitive trait empathy were not significantly related to motor empathy in response to happiness. Thus, we did not find strong support for a link between trait empathy and motor empathy. This is not inconsistent with previous research that also did not provide strong support for such a relation (e.g., Achaibou et al., 2008; Fabes et al., 1993; Sonnby-Borgström et al., 2003). Although differences in motor empathy between high and low affective trait empathy groups have been reported in studies using pictures of prototypical posed happy and angry facial expressions (Dimberg & Thunberg, 2012), in two studies such group differences were only significant at short stimulus exposure times during which the stimuli could hardly be consciously perceived (Sonnby-Borgström, 2002; Sonnby-Borgström et al., 2003).

When participants were longer exposed to the stimuli so that they could be consciously perceived, group differences were not significant. Further, most of the studies that found positive associations between trait empathy and motor empathy assessed trait empathy directly before or after the state empathy assessment, which may have inflated the trait–state associations (e.g., Eisenberg et al, 1988; Westbury & Neumann, 2008). The substantial time period between the measurement of trait empathy (during a home visit) and state empathy (during a test session at the university) in the current study, might explain why we found few significant trait–state relations.

With regard to the associations between trait empathy and the verbal state empathy measures, we did find the expected positive associations in several cases, particularly in response to sadness. Adolescents who reported higher affective trait empathy reported higher affective state empathy in response to sadness, and adolescents who reported higher cognitive trait empathy also showed higher levels of cognitive state empathy in response to sadness. Also, higher affective trait empathy (and for girls also cognitive trait empathy) was positively related to affective state empathy in response to happiness. However, the magnitude of the associations was modest. Thus, in line with our hypothesis, we found positive relations between trait and state empathy measures although associations were more consistent for sadness than for happiness. This finding may be due to the fact that the measure we used to assess trait empathy (IRI; Davis, 1983) particularly focuses on empathy with others' sadness or distress. Previous studies on the interrelations between trait and state empathy make no distinction between different emotions, and most measures mainly reflect empathy with others' sadness (e.g., Eisenberg et al., 1988, 1994). Thus, our study extends previous research by differentiating between state empathy with happiness and sadness. Our findings suggest that individual differences in affective and cognitive trait empathy play a modest role in affective and cognitive state empathy, and that empathy with sadness should be distinguished from empathy with happiness.

The measurement of empathy

The modest effect sizes of the associations of the trait empathy measures with our measure of motor empathy, as well as the pattern of sex differences in mean levels across the measures, suggests that demand characteristics may play a role in the self-reported measures, and in particular in the trait empathy measures. Consistent with the literature, girls overall reported higher levels of both affective and cognitive trait empathy than boys (e.g., Lennon & Eisenberg, 1987; Rueckert & Naybar, 2008), with the strongest sex differences on affective trait empathy (e.g., Davis & Franzoi, 1991; Hoffman, 1977). Interestingly, sex differences were smaller on the state empathy measures than on the trait empathy measures (in particular, *affective* trait empathy), and there were no significant sex differences at all in motor empathy. That is, girls did not show stronger corrugator activity in response to sadness, or stronger zygomaticus activity in response to happiness than boys although boys showed less inhibition of corrugator activity (i.e., frowning) in response to happiness. These findings of the largest sex difference on affective trait empathy, only small sex differences on self-reported state empathy measures, and majorly absent differences on facial EMG measures, support the notion that social desirability and gender stereotypes play a role in adolescents' self-reports of empathic tendencies. When it is obvious that (particularly affective) empathy is assessed, boys seem for instance to be less willing to report themselves as empathic as girls (Hoffman, 1977; Lennon & Eisenberg, 1987). The fact that demand characteristics likely have played a larger role in the trait empathy assessments than in the state empathy assessment, may also be an explanation for the modest effect sizes of the trait–state associations.

Limitations

Even though major strengths of the current study are the comprehensive design, the relatively large sample size and the use of the highly sensitive EMG technique to measure adolescents' motor empathy, our results should be interpreted in light of some limitations. First, due to the correlational design of the current study, we cannot address the direction of effects in our models. Our findings show that the observation of emotional film clips evoked the corresponding motor responses in the participants, but instead of being an automatic reaction to the stimuli, the motor responses may have resulted from the emotional experience that was also evoked by the stimuli. Second, although an important strength of the current study is the use of different measures to assess the affective and cognitive dimensions of empathy, a limitation is that our trait and state measures of affective and cognitive empathy did not assess exactly the same aspects of these dimensions. For instance, whereas our affective trait empathy measure assessed the tendency to sympathise with others, our affective state empathy measure assessed pure affective empathy, or the vicarious experience of emotions consistent with those of the observed person. These differences in focus of trait and state measures may partly explain the modest associations we found between trait and state empathy. Third, although our facial EMG measurement of the corrugator and zygomaticus muscles revealed the expected motor empathy in response to happiness and sadness, we cannot exclude the possibility that these motor responses are primarily a response to a general negative emotional experience in the case of corrugator activity, and a response to a general positive experience in the case of zygomaticus activity, rather than motor empathy associated with specific target emotions (Hess & Fischer, 2013). Corrugator and zygomaticus tend to exhibit a generalised increase in activity in response to stimuli with a negative or positive emotional valence, respectively, irrespective of the specific type of emotion elicited by the stimulus (Larsen et al., 2003; Overbeek, Van Boxtel, & Westerink, 2012). Finally, our study involved adolescents, and results can therefore not be extrapolated to other age groups. Moreover, even within the period of adolescence, our results might have been different if our assessments were conducted at age 13 instead of age 17, for instance regarding the results on gender differences in empathy. Previous research has revealed marked gender differences in developmental trends in trait empathy during adolescence (Van der Graaff et al., 2014). We recommend future research to include assessments of both trait and state empathy when studying developmental trends in empathy.

CONCLUSION

Despite the limitations, the current study advances our understanding of the multi-dimensional construct of empathy by using a multi-measure design which captured motor, affective and cognitive processes related to state empathy, as well as the trait dimensions of empathy. In accordance with theories that assume motor empathy to be related with the experience of emotions (Hatfield et al., 1994; Preston & De Waal, 2002), we consistently found adolescents who showed stronger motor empathy to have experienced higher affective state empathy. In line with the facial feedback hypothesis (Hatfield et al., 1994), adolescents who showed stronger motor empathy, not only experienced higher affective empathy, but also showed higher levels of cognitive state empathy. Interestingly, consistent but modest trait–state associations were found for state empathy with sadness.

To our knowledge, this study is the first to include facial EMG measurement of motor empathy together with trait and state measures of both cognitive and affective empathy. The modest magnitude of the effect sizes that our study revealed provides support for the notion that empathy is a multi-faceted phenomenon (Batson, 2009); motor, affective and cognitive empathy seem to be related processes that each play a different role in the ability to understand and share others' feelings.

Disclosure statement

No potential conflict of interest was reported by the authors.

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