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Research Report

Perspective taking is associated with specific facial responses during empathy for pain

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ABSTRACT

Witnessing the distress of others can result both in empathy and personal distress. Perspective-taking has been assigned a major role in the elicitation and modulation of these vicarious responses. However, little is known about how perspective-taking affects the psychophysiological correlates of empathy vs. personal distress. We recorded facial electromyographic and electrocardiographic activity while participants watched videos of patients undergoing painful sonar treatment. These videos were watched using two distinct perspectives: a) imagining the patient's feelings ('imagine other'), or b) imagining to be in the patient's place ('imagine self'). The results revealed an unspecific frowning response as well as activity over the M. orbicularis oculi region which was specific to the 'imagine self' perspective. This indicates that the pain-related tightening of the patients orbits was matched by participants when adopting this perspective. Our findings provide a physiological explanation for the more direct personal involvement and higher levels of personal distress associated with putting oneself explicitly into someone elses shoes. They provide further evidence that empathy does not only rely on automatic processes, but is also strongly influenced by top-down control and cognitive processes.

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1. Introduction

Imagining how one would feel in someone else's place has been acknowledged as an important factor in the experience of empathy. As far back as the eighteenth century, the Scottish moral philosopher and economist Adam Smith proposed that we project ourselves into the place of others by using our imagination, thereby entering their worlds and bodies and becoming in some sense the same person. Contemporary approaches support this notion by showing that witnessing someone else's emotions using different perspectives can result in distinct psychological, motivational and behavioral outcomes (e.g., Batson et al., 2007; Batson et al., 1997b; Underwood and Moore, 1982).

In particular, the likelihood of altruistic action is modulated by whether we imagine how *another* person feels ('imagine other') *vs.* how *we* would feel ('imagine self') in a particular situation. These are two distinct forms of perspective taking carrying different emotional consequences (Batson et al., 1997a; Batson et al., 2003). While both strategies may promote empathic concern, the instruction to explicitly put oneself into the other's shoes also increases personal distress (i.e., a self-oriented aversive emotional response). In two functional neuroimaging studies, we investigated the neural correlates of perspective taking on the perception of

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pain in others (Jackson et al., 2006; Lamm et al., 2007a). The main finding of these studies was that witnessing another's pain using a first-person perspective recruits areas involved in the first-hand experience of pain more extensively than the more detached and other-oriented imagine-other perspective. This was indicated by higher activation in key structures involved in coding affective-motivational aspects of painful experiences, such as the amygdala, the mid-insula and the medial cingulate cortex. Signal changes in the thalamus, primary and secondary somatosensory cortices, and in ventral and dorsal premotor areas also suggest that imagining oneself to experience the pain of others recruits areas coding the sensory and motor aspects of pain.

These studies also document that both types of perspective taking are powerful elicitors of emotions. This was a prerequisite for the current study which aimed to evoke the sharing of affect between observer and target in order to investigate their physiological concomitants (Lang et al., 1980). Apart from the pioneering investigations by Stotland (1969), though, little is known about how perspective-taking affects the peripheral nervous system's correlates of empathy.

The purpose of the present study was to fill this gap. We explored how perspective taking affects the electromyographic (EMG) and electrocardiographic responses to watching the facial expression of pain. To this end participants watched videos of patients undergoing painful sonar treatment. The videos were watched using two distinct perspectives: a) imagining the patient's feelings ('imagine other'), or b) imagining themselves being in the patient's place ('imagine self'). EMG was recorded over two muscles involved in expressing pain — the Musculus orbicularis oculi, controlling orbit tightening, and the Musculus corrugator supercilii, drawing the eyebrows down and together into a frown (e.g. Craig et al., 2001). In addition, we monitored stimulus-induced heart rate changes and EMG activity over two unspecific control sites. Our aim was to explore whether the two different perspective-taking conditions result in distinct psychophysiological responses, and whether these responses are in line with the higher levels of personal distress and empathic concern determined on the behavioral level.

2. Results

2.1. *Behavioral and dispositional measurements*

The perspective taking instructions did not result in significantly different pain intensity ratings ($t(26) = 1.029$, $P = 0.313$, partial $\eta^2 = 0.039$). Mean ratings were 61.96 (S.E. 2.36) for the other-perspective, and 60.09 (S.E. 2.59) for the self-perspective. The mean ratings in both conditions correlated significantly with the emotional contagion scores ($r = 0.470$, $P = 0.013$, for imagine other, $r = 0.462$, $P = 0.015$, for imagine self). None of the other scales correlated with the pain intensity ratings.

The exit interview revealed high levels of compliance with the instructions. Debriefing also showed that no participant was explicitly aware that the main aim of the study was to measure their facial expressions in response to the videos.

2.2. *Electromyography*

Visual inspection of the EMG time-courses revealed a decrease in EMG amplitude in all channels immediately upon presentation of the neutral face – irrespective of the adopted perspective. Following this decrease, signals remained stable for the left forearm and the M. medio-frontalis, and partially

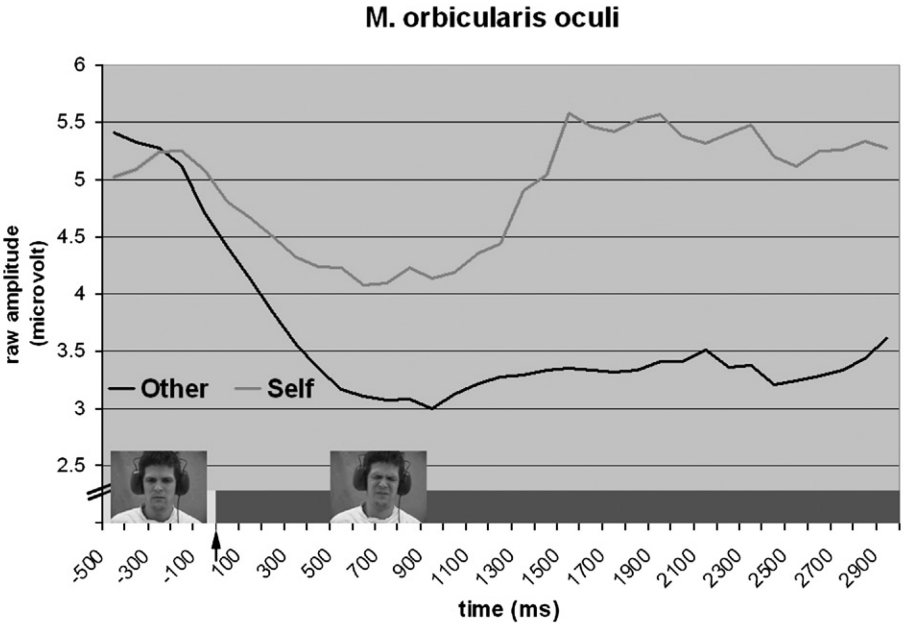

Fig. 1 – Signal amplitudes of M. orbicularis oculi during the self- and other-perspectives. The first 500 ms are related to viewing the neutral facial expression (indicated by the light grey bar and the neutral facial expression), which transitions into the expression of pain during the subsequent 3000 ms (dark grey bar and painful expression, onset of painful expression marked by arrow).

rebounded to the pre-stimulus level for the M. corrugator supercilii in both perspective conditions. Most notably, a large and distinct increase above pre-stimulus levels was observed for M. orbicularis oculi, but only in the imagine-self condition (Fig. 1; main effect PERSPECTIVE: $F(1,26) = 8.595$, $P = 0.007$, partial $\eta^2 = 0.248$; interaction PERSPECTIVE×TIME: $F(34,884) = 3.957$, $\varepsilon = 0.1$, $P_{\mathrm{adj.}} = 0.008$, partial $\eta^2 = 0.132$). As for M. corrugator supercilii, M. medio-frontalis and the left forearm, none of the main effects or interactions was significant or close to significant (all $Ps > 0.398$). Post-hoc tests for M. orbicularis oculi revealed a significant signal decrease after the onset of the neutral face which persisted until the onset of the painful facial expression for both perspectives (contrast of mean amplitude of the first 100ms of neutral face vs. the first 100ms of painful face; imagine other: $F(1,26) = 9.499$, $P = 0.005$, partial $\eta^2 = 0.365$; imagine self: $F(1,26) = 6.962$, $P = 0.014$, partial $\eta^2 = 0.268$). The amplitude of this signal decrease was not different between perspectives ($F(1,26) = 0.439$, $P = 0.513$, partial $\eta^2 = 0.017$).

M. orbicularis oculi amplitudes in the self-perspective were higher during presentation of the neutral face ($F(1,26) = 5.195$, $P = 0.03$, partial $\eta^2 = 0.2$). Since this initial difference might have affected the subsequent pain-related amplitude changes, we wanted to make sure that the actual signal differences during watching the facial expression of pain were not affected by this initial difference. To this end, we subtracted the mean signal during presentation of the neutral face ('baseline') from all following 30 pain-related mean amplitude values and performed an additional ANOVA with these baseline-subtracted values. This ANOVA confirmed the results of the raw data ANOVA (significant main effects of PERSPECTIVE and interaction PERSPECTIVE×TIME). Thus, the pain-related increases in EMG activity cannot be explained by the differences in EMG during presentation of the neutral face. Furthermore and in line with the raw data, the baseline-corrected values clearly demonstrate an almost perfectly linear increase of signal amplitude starting around 500ms after onset of the facial expression of pain, reaching a plateau around 1s after onset of the painful expression which persisted until stimulus offset (see Fig. 2).

Additional planned tests of the M. corrugator supercilii response showed a significant rebound to baseline levels after signals had achieved their minimum around 1000ms post-stimulus (contrast of mean amplitude 200–600ms vs. mean 1000–3000ms, both after pain stimulus onset; $F(1(1,26) = 5.915$, $P = 0.02$, partial $\eta^2 = 0.227$; Fig. 3). This rebound, however, was independent of the adopted perspective ($F(1,26) = 0.214$, $P = 0.648$, partial $\eta^2 = 0.008$). In addition, at no point in time did the two perspectives differ significantly in M. corrugator supercilii activity. This lack of differences despite the seemingly high differences in grand mean amplitudes is related to considerable inter- and intra-subject variability. Single-subject analyses of time-courses also revealed that the response pattern of M. corrugator supercilii was different from M. orbicularis oculi. While M. orbicularis oculi showed sustained activity after pain onset in the imagine-self condition, M. corrugator supercilii responded in a more phasic way with short deflections or activity bursts that were less time-locked across participants and trials.

2.3. *Electrocardiographic changes*

In both conditions, stimulus presentation triggered a considerable heart rate deceleration of about 10ms (Fig. 4). These changes were not significantly modulated by the adopted perspective and neither was the base heart rate [PERSPECTIVE $F(1,24) = 1.764$, $P = 0.197$, partial $\eta^2 = 0.068$; PERSPECTIVE×TIME $F(8,192) = 0.847$, $\varepsilon = 0.280$, $P = 0.847$, partial $\eta^2 = 0.008$]. Post-hoc tests revealed no perspective-related differences in absolute

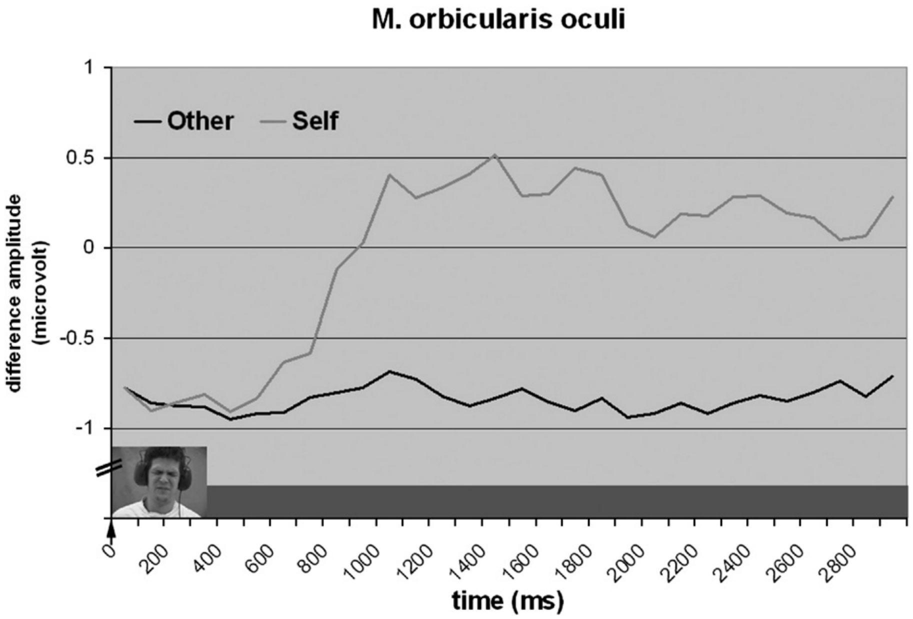

Fig. 2 – Differences between pain stimulus-related signals and mean activity during viewing the neutral face (baseline-corrected values), showing a selective increase in activity starting around 500 ms post-stimulus (see Fig. 1 for specifications).

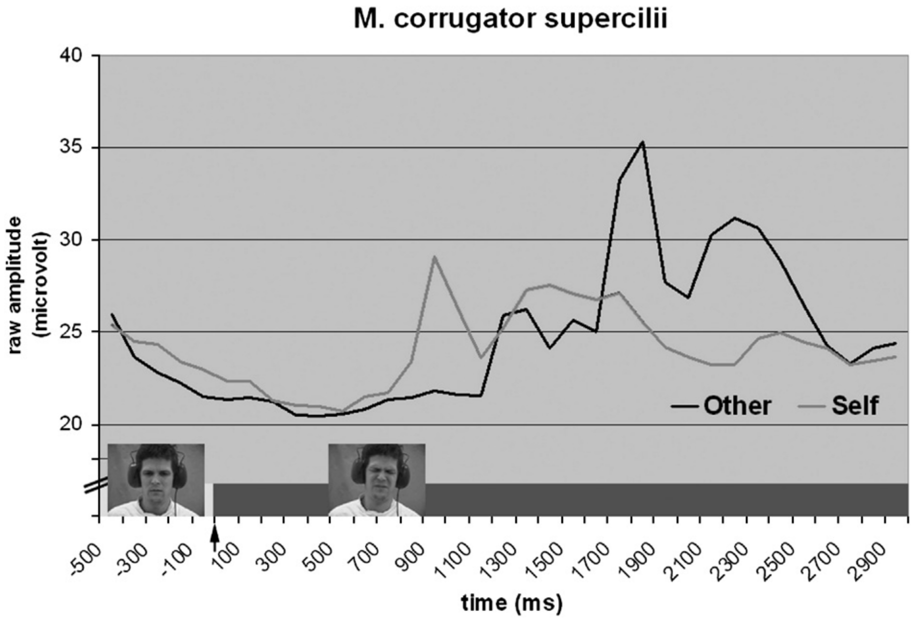

Fig. 3 – Signal amplitudes of M. corrugator supercilii during the self- and other-perspectives, showing knitting-related EMG increases that do not significantly differ between conditions (see Fig. 1 for specifications).

interbeat intervals at any point in time, nor any perspective-related differences in heart rate acceleration or deceleration. In addition, we assessed whether the maximum heart rate decelerations during stimulus presentation (i.e., maximum deviation from pre-stimulus baseline, individually determined for each participant) differed between conditions. This was not the case (paired *t*-test, $t(24) = 0.152$, $P = 0.880$, partial $\eta^2 = 0.001$). Note also that the changes in heart rate cannot be explained by a change in respiratory rate which – due to its low frequency – would have affected heart rate at a much later point in time than the rather immediate deceleration at around 1s post-stimulus. Besides, respiratory rates in the two conditions were virtually identical (M = 17.93/min vs. 17.92 for imagine other and self, respectively).

2.4. *Correlation of dispositional and psychophysiological measures*

In order to reduce the likelihood of false positives, we only computed correlation analyses for concrete hypotheses derived

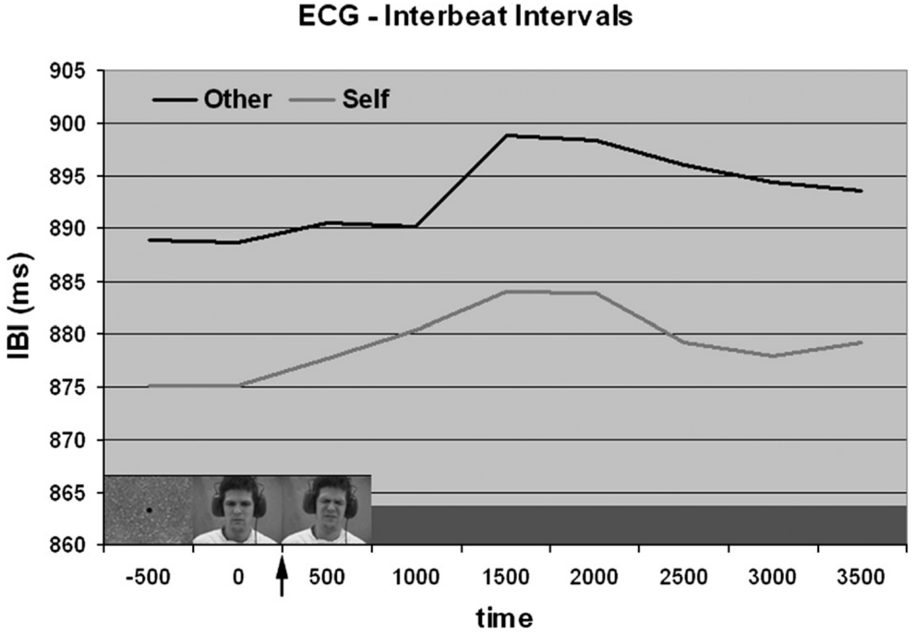

Fig. 4 – Interbeat intervals (in ms) during the self- and other-perspectives. The scrambled image indicates the pre-stimulus baseline, other specifications as in Fig. 1.

from the results or from theoretical considerations. We tested whether the observed signal difference in M. orbicularis oculi (mean difference from video onset until offset) was correlated with the empathic concern and perspective taking scores of the IRI, the affective empathy scale, or with the score of the emotional contagion scale. In addition, we assessed whether stimulus-induced heart rate changes (interbeat interval difference between maximum change and pre-stimulus baseline) correlated with these questionnaire measures.

Correlations of the M. orbicularis oculi difference with the perspective taking score were significant ($r = 0.388$, $P = 0.046$) and close to significance for the emotional contagion score ($r = 0.338$, $P = 0.085$). The positive correlations signified that higher positive signal differences were associated with higher questionnaire scores. No significant correlation was observed for the empathic concern and the affective empathy scale, and there was no significant correlation between questionnaire measures and heart rate changes.

3. Discussion

Using a well-validated experimental paradigm we assessed whether the perspective with which a target's pain is witnessed modulates EMG and heart rate responses. In addition, we assessed whether EMG and ECG responses are related to dispositional differences in empathy, emotional contagion or perspective taking. The main insights from this study are that

- activity of M. orbicularis oculi is specifically modulated by imagining someone else's pain, closely matching the target's facial expressions only during the imagine-self condition,
- this modulation of M. orbicularis oculi activity positively correlates with perspective taking abilities and emotional contagion scores, and that
- M. corrugator supercilii and heart rate respond to the facial display of pain with a response that is independent of the adopted perspective.

3.1. *Modulation of facial EMG*

The most compelling finding is the modulation of M. orbicularis oculi by perspective-taking. This modulation suggests a close and consistent matching of the target's facial expressions with one's own expressions, but only during the imagine-self perspective. This matching is indicated by the onset of the EMG signal increase and its sustained amplitude until video offset. No such response is present during the other-perspective, speaking against the interpretation of automatic mimicry for this facial region (if automaticity is, in its strictest sense, interpreted as a non-intentional and non-controllable process; Bargh, 1994). The response pattern of the M. orbicularis oculi therefore indicates a selective influence of top-down processing on facial activity. Also, the difference in M. orbicularis oculi EMG between conditions was positively correlated with the ability to take the perspective of another person, as measured by self-report.

Furrowing of the brows in response to aversive or negative stimuli – including pain – is a well-described phenomenon. Several studies show that the M. corrugator supercilii reacts to a variety of stimuli such as angry or fearful faces (Bradley and Lang, 2000; Cacioppo et al., 2000; Larsen et al., 2003, for review). The response of the M. corrugator supercilii EMG in both conditions is therefore well in line with these reports, demonstrating susceptibility to the experience, observation or representation of negative affect. In the current study, activity over the M. corrugator supercilii region could be interpreted in two ways. One interpretation is that it is related to mimicry of the target's furrowed brows — which is one of the most dominant facial movements during pain (see Fig. 5 for an example). Alternatively, the amplitude changes could be related to the general discomfort triggered by exposing participants to an aversive and unpleasant event (see also Magnee et al., 2007). It is worth noting that numerous studies demonstrating M. corrugator supercilii responses to aversive stimulation used non-facial and even non-corporeal stimuli such as aversive or unpleasant photography, sounds, or words — indicating that its susceptibility to aversive events is not exclusively related to mimicry of facial expressions (Bradley, 2000; Cacioppo et al., 2000, for review). We therefore favor the interpretation that EMG activity of M. corrugator supercilii in our study is related to the expression of negative affect.

This interpretation receives additional support by the time-course of activity, which revealed intermittent activity bursts instead of continuous stimulus-locked activity. These bursts might reflect brief moments of distress and discomfort rather than a sustained matching of the target's dynamic emotional display — such as it was observed over the M. orbicularis oculi region. However, future investigations modulating the intensity of pain as well as introducing temporal variations of the facial expression are necessary to disentangle the different processes that are at play here. Note also that the observed effects are not unspecific responses to the presentation of a visual stimulus as the pain expressions were preceded by the presentation of a neutral face, as well as by a luminance-matched baseline image.

In addition to – in our view – the absence of a generalized mimicry response, M. corrugator supercilii EMG was not differentially involved in the two perspective taking conditions. The higher sensitivity of the M. orbicularis oculi to context effects during the perception of pain in others is in line with earlier reports by the group of Lanzetta (Englis et al., 1982; Lanzetta and Englis, 1989). These reports demonstrated that M. orbicularis oculi as opposed to M. corrugator supercilii, M. masseter and M. medio-frontalis shows the most pronounced modulation during counter-empathy experiments. In these experiments, participants viewed game play partners that either cooperated or competed with them. While watching a cooperative partner receiving electric shock triggered matched responses in M. orbicularis oculi, no such response was obtained for non-cooperative targets. Similar effects were observed for skin conductance and heart rate changes. Importantly, these studies also show that the responses to a target's facial expression of pain do not follow an all-or-none law, but can be modulated by the relationship between empathizer and target. In line with our results, the shown flexibility of physiological and behavioral responses casts some doubt on the notion of automatic and predominantly bottom-up driven emotional contagion during interpersonal interactions (see also Hatfield et al., 2008).

3.2. *Modulation of heart rate*

The heart rate response pattern is largely consistent with the previously described triphasic response – an initial deceleration followed by short acceleration and a second deceleration – triggered by viewing pictures with affective content (Bradley and Lang, 2000). The initial deceleration of heart rate is a well-documented finding and may be related to a variety of factors — including general stimulus-related responses such as attention and anticipation (Lacey et al., 1963; Porges, 1992), but also the processing of negative affect (Bradley et al., 1993; 2001). Alternatively, the deceleration might be related to some sort of 'freezing behavior' recently reported for viewing pictures of mutilation (Azevedo et al., 2005). The absence of condition effects indicates that heart rate was not directly affected by the viewing perspective. This suggests that the higher personal distress in the self-perspective is not captured by heart rate or heart rate changes. As a note of caution, however, the mean IBI values showed a higher heart rate – albeit non-significant – in the self-condition. This might indicate a small effect size that could not be appropriately captured by the chosen sample size. Note also that the decrease in EMG activity in all channels upon stimulus presentation might be related to similar factors as the heart rate deceleration. The stimulus-contingent muscular relaxation might reflect the transition from a slightly anxiety-inducing state of anticipation as well as of the attentionally demanding dot fixation to a more task-oriented and stimulus-driven task processing mode. A similar phenomenon has been reported by Dimberg et al. (2000) when using a warning stimulus allowing stimulus prediction.

3.3. *Perspective taking and empathy for pain*

The present study supports theoretical concepts defining empathy as a complex interplay of bottom-up and top-down processes (e.g., Decety and Lamm, 2006; Goubert et al., 2005). Our findings are in line with a number of recent social neuroscience studies showing that the way in which a target's pain is appraised or attended results in distinct neural activation patterns (e.g., Cheng et al., 2007; Gu and Han, 2007; Lamm et al., 2007a; 2007b; Lamm and Decety, 2008; Singer et al., 2006). It remains to be addressed, however, what kind of top-down process drives the modulation of M. orbicularis oculi activity. We suggest that it stems from using two affective imagery strategies with distinct behavioral outcomes. The imagine-other condition required participants to adopt a more perception-driven and less subjective view of the situation. Notably, the explicit instruction to direct attention towards the facial displays of pain did not result in increased facial EMG activity. This represents another argument against the occurrence of automatic mimicry, as such mimicry should have been more prevalent by the increased attention to the facial expressions. On the other hand, the imagine-self condition is driven less by the perception of the target, but requires a more immediate personal involvement of participants. This assumption is supported by higher levels of personal distress (Batson et al., 1997a; 2003; Lamm et al., 2007a), and by increased neural activation in brain structures associated with the direct experience of affect and of sensori-motor processing (Jackson et al., 2006; Lamm et al., 2007a). We suggest that the mechanism for this higher personal involvement is the more extensive use of motor imagery. Motor imagery is known to activate somaesthetic and motor representations associated with the imagined movements and the somatosensory feedback generated by them (e.g., Michelon et al., 2006; Naito et al., 2002). It also carries a distinct and well-described neural signature which strongly involves cortical somatosensory and premotor areas, in particular when compared to third-person imagery (e.g., Ramnani and Miall, 2004; Ruby and Decety, 2004). Also recent fMRI results show medial and lateral premotor cortex activation when using a very similar design as in the present study (Lamm et al., 2007a). Interestingly, motor imagery is also associated with specific changes in EMG activity and sometimes even with overt movement — such as during mental training or rehearsal of motor sequences by athletes or musicians (Guillot et al., 2007). The more extensive use of motor imagery from a first-person perspective might therefore explain why the imagine-self perspective results in a more self-centered response and a reduction in empathic concern — compared to the more altruistic and other-oriented response associated with the imagine-other perspective.

4. Conclusion

Our findings extend our knowledge about the processes involved in empathy for pain. They show that understanding others and feeling what they feel is not only an automatic process relying on somatic and motor resonance. Rather it can also be shaped by top-down control and cognitive processes. The interaction between bottom-up and top-down processes is expressed on a variety of levels, ranging from simple motor reactions over cardiovascular and autonomic changes up to more elaborate cognitive and affective representations of the other's state. The higher activity over the M. orbicularis oculi region provides another piece of evidence that using a first-person perspective results in a more direct involvement when witnessing others in distress. The well-documented higher personal distress associated with that perspective might therefore partially result from a decreased ability to distinguish the self from the other, resulting in more egoistic response tendencies rather than attempts to alleviate the other's distress.

5. Experimental procedures

5.1. *Participants*

Thirty healthy volunteers participated in this study (18 females, age range 18–30, right-handed according to self-report). The study was approved by the local ethics committee (Social and Behavioral Sciences Institutional Review Board, The University of Chicago) and conducted in accordance with the Declaration of Helsinki. All participants gave informed written consent and were paid for their participation. No subject had any history of neurological, psychiatric or major medical disorder.

5.2. *Experimental design and procedures*

Standardized instructions informed participants that they would watch video clips of patients experiencing pain due to (voluntary) sonar medical treatment (Fig. 5), and that clips should be watched adopting two different perspectives (within-subjects design, conditions imagine-self vs. imagine-other). In the imagine-self condition, participants read the following instruction: "Imagine that you are in the place of the patient and that you are receiving the painful auditory treatment. Imagine that you are experiencing the pain when listening to the sound", while the instruction for the imagine-other perspective was as follows: "Imagine how the patient feels while receiving the painful auditory treatment and how he/she is affected by it. Imagine the patient's emotional response as he/she experiences the painful treatment." In both cases, the fact was stressed that both perspectives should be used to accurately infer the patient's experience of pain. Thus, the crucial difference between the two instructions was that the imagine-self perspective required participants to imagine how they would feel themselves in the target's situation in order to feel his or her pain, while the imagine-other instruction asked them to adopt a perspective in which the focus of attention was to imagine the target's feelings by focusing on his or her overt expressions.

Before starting the experiment, several practice trials were run to familiarize participants with the stimuli and the experimental design. Then, five different videos for each perspective were presented in two blocks. Before each block, an instruction screen indicated the perspective that had to be adopted for the upcoming five videos, which had been taken from five different patients (3 male, 2 female). All videos showed a neutral facial expression, which after 500ms changed to a painful expression for 3000ms. Different patients were shown in the two perspective taking conditions to avoid memory effects and familiarity confounds, but patients expressed very similar levels of pain as determined by extensive stimulus validation (Lamm et al., 2007a). All video clips displayed brow lowering, orbit tightening, and either cursing or pressing of the lips, or mouth opening or stretching. These movements have consistently been attributed to the facial expression of pain (e.g., Craig et al., 2001). In order to control for the intensity of visual stimulation and to reduce muscular and arousal responses to luminance changes, luminance-matched scrambled baseline images with a centered fixation dot were shown during intertrial intervals (ITIs). Mean ITI duration was 5300ms, and ITIs were randomly jittered to reduce stimulus predictability (range 3500–7500ms). Block order and patient assignment to conditions were counterbalanced across participants.

In additional blocks performed after the main experiment, participants rated the pain experienced by the patients (nine trials per perspective). Ratings were entered using a visual analogue scale ranging from no pain (coded as 0) to worst imaginable pain (coded as 100). Responses had to be entered with the dominant right hand, using a keyboard placed in front of the participant. After these runs, a structured semi-standardized exit interview was performed. A set of questionnaires was filled in a week before the actual experiment and with participants being blind to its purpose in order to

Fig. 5 – Example of the used video stimuli. The five extracted frames show the transition from a neutral facial expression to a startle-response (frame 2) and the full-blown facial expression of pain (frames 3–5), which is characterized by knitted brows, orbit tightening, mouth stretching and a raised upper lip.

assess individual differences in empathy and affective responding. Questionnaires included the Interpersonal Reactivity Index (IRI; Davis, 1994), the Emotional Contagion Scale (ECS; Doherty, 1997, and a scale measuring affective empathy (Mehrabian and Epstein, 1972). The IRI is the most widely used self-report measure of dispositional empathy. Its four subscales (empathic concern, perspective taking, fantasy scale and personal distress) assess different aspects of empathic responses. The ECS assesses the susceptibility to other's emotions from afferent feedback generated by mimicry, using questions such as “I clench my jaws and my shoulders get tight when I see the angry faces on the news”. The measure of affective empathy was included as a complementary measure of empathy.

5.3. *Psychophysiological measurements and analysis*

All psychophysiological measurements were performed using the AcqKnowledge data recording software (version 3.8.1), running on a Windows XP computer and connected to a set of Biopac amplifiers connected to a Biopac MP 100 A A/D digitization system (digitizing signals at 1kHz; Biopac Systems, Inc., Santa Barbara, CA, USA). Heart rate was recorded using a MindWare MW2000D amplifier (MindWare Technologies LTD, Gahanna, OH, USA). The grounding electrode for all measurements was placed below the left collarbone. MindWare (version 2.51), CardioBatch (version 1.1) and CardioEdit (version beta) were used to inspect, analyze and extract psychophysiological data, and SPSS (version 12.0.1, SPSS Inc., Chicago, IL, USA) and STATISTICA (version 5.1, StatSoft Inc., Tulsa, OK, USA) were used for statistical analyses. In case of violations of the sphericity assumption, repeated measures analyses of variance were corrected using Greenhouse–Geisser degrees of freedom adjustment, and linear contrasts were computed using specific error variances (Boik, 1981). Three subjects had to be excluded from the EMG analyses and five from the ECG analyses due to equipment failure or inability to complete the experiment due to discomfort, yielding a final sample of 27 participants (16 females). Therefore, Kolmogorov–Smirnov tests along with visual inspection of data distributions were performed to make sure that the data met the normality assumption requirement of the performed parametric statistics.

5.4. *Electromyography*

EMG was recorded from three facial and one extra-facial site (left forearm). Recordings from the left forearm were acquired to assess general bodily mimicry as expressed by tensing of the skeletal musculature. Facial EMG was recorded over the regions of the orbicularis oculi, the corrugator supercilii, and the M. frontalis, pars medialis (M. medio-frontalis). The first two muscles were expected to be activated by the observation of orbit tightening and of down- and inward eye brow movements. In contrast, activity over the M. medio-frontalis was measured to establish discriminant validity as it raises the eyebrows and hence should not be related to pain mimicry. All electrodes were placed on the left side of the face, and electrodes were placed according to the guidelines developed by Fridlund and Cacioppo (1986). Signals were recorded using shielded non-polarizable miniature Ag/AgCl surface electrodes (Biopac, EL 208 S) filled with Biopac electrode gel and amplified bipolarly by Biopac EMG100 systems (bandpass from 1Hz to 500Hz). Alcohol and abrasive electrolyte paste were used to keep input impedance below 5kΩ, which was individually verified using an impedance meter. Several checks (raising and furrowing the brows, arm tightening, squinting, deep breathing, performing mental arithmetic) were performed to ensure proper electrode placement and recording setup. Participants were told that all electrodes were ‘sensors recording their physical responses to the videos’. The words mimicking, mimicry, empathy and imitation were carefully avoided in order to avoid priming participants or making them suspicious about the purpose of the experiment.

Following visual screening and the exclusion of artifact-contaminated trials, the full-rectified EMG signal for each trial was averaged in 100ms epochs from 500ms before the video clip's onset until its offset. The resulting values were averaged across all trials of a participant and entered into a repeated measures analysis of variance with factors PERSPECTIVE (self vs. other) and TIME (35 peri-stimulus measurements).

5.5. *Electrocardiographic recordings*

ECG was recorded from standard ECG electrodes (Silver Trace electrodes, GE Medical Systems, Milwaukee, WI, USA) placed on the right collarbone and the left lower ribcage. Electrodes were bipolarly connected to a MindWare MW2000D amplifier. In addition, impedance cardiography was applied to measure respiration rate. Respiration rate was used to exclude participants with abnormal or irregular breathing patterns (which were not observed for any of the included participants) and to exclude trials with respiration anomalies since they adversely affect heart beat measurements. Analysis of ECG data consisted of manually supervised automatic R-wave peak detection and the subsequent calculation of interbeat intervals. Event-related interbeat interval changes were calculated in 500ms increments from 500ms before stimulus onset until stimulus offset, and trial averages were entered into a repeated measures analysis of variance with factors PERSPECTIVE (self vs. other) and TIME (8 peri-stimulus measurements).

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