Chapter 8
Behavioural/Facial Markers of Pain, Emotion, Cognition

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Abstract Behavioural/facial markers of pain refer to a variety of responses that typically accompany the experience of pain. They serve the purpose to communicate the inner state "pain" to others and thus play a crucial role in social interactions. Moreover, they can also serve the purpose to protect affected body areas from pain and hereby promote healing. This chapter will give an overview of these behavioural markers of pain, with a specific focus on facial activity. Descriptions on what these responses look like, how they can be analysed, which aspects of pain they encode and how they can be differentiated from behavioural responses to other types of emotional affective states will be given. Moreover, since behavioural markers of pain are of special importance in patients with cognitive impairments (who are often not able to report about their pain), the impact of cognition on behavioural responses to pain will be discussed.

8.1 Introduction

The experience of pain is typically accompanied by a certain set of behavioural responses. A comprehensive conceptual framework for these behavioural responses is provided in Chap. 2. Some of the pain-related behavioural responses can be nicely observed in football matches (aka soccer), where football players who are hit by an opposing player can often be seen falling to the ground, clutching the affected body part, rolling about, grimacing and groaning. Commonly these behavioural responses are divided into three groups, namely, facial expressions, body postures/movements and paralinguistic vocalisations (Craig et al. 2010). This chapter will mainly focus on facial expressions, given that facial expressions of pain have been studied extensively, whereas little is known about the two other groups of pain behaviours. It is believed that the broader domain of behavioural responses accompanying the experience of pain serves two purposes, which are (1) a communicative function and (2) a pain management function (Prkachin 1986; Williams 2002). Facial

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expressions and vocalisations both seem to have a primary communicative function by rapidly informing others that one is experiencing pain and thus warning others and/or eliciting empathy and solicitous behaviours in others. In contrast, body postures/movements are believed to have a primary pain management function. For example, rubbing or holding the affected body part seems to mainly serve the purpose of protecting the self from pain and promoting healing. However, even if pain management might be the primary function, pain-related body postures/movements do of course also have a communicative value, given that certain postures and movements can easily be detected as pain indicative by observers (Prkachin 1986). Likewise, facial expressions and vocalisations – although having a primary communicative function – might also have a pain management function. For example, closing of the eyes – a movement often occurring in the context of pain – might shield the individual from the noxious and physically threatening stimulus. Therefore, behavioural markers of pain seem to have evolved to serve communicative as well as pain management functions.

The aim of this chapter is to give an overview of behavioural responses (with a special focus on facial expressions) occurring in the context of pain and to describe what they look like, their variability, which aspects of pain they encode, how they can be differentiated from behavioural responses to other types of affective states and whether they are altered in those with impaired cognitive functioning.

8.2 Facial Responses to Pain

Amongst the three categories of non-verbal behavioural responses to pain, namely, facial expressions, vocalisations and body movements, the *facial expression* of pain has been studied most extensively. Especially in the last two decades, a considerable number of studies have been conducted that try to analyse the "characteristic" features of facial expressions of pain and which bio-psychosocial factors might impact the way we facially express pain (Hadjistavropoulos et al. 2011). The reason why research on pain behaviour has mostly focused on the facial expressions of pain is that facial expressions are readily accessible, are highly plastic, and are believed to be the most specific, encodable form of pain behaviour in humans (Williams 2002).

8.2.1 Which Methods Can Be Used to Analyse Facial Responses?

One of the first instruments developed for the assessment of non-verbal behaviour is the Facial Action Coding System (*FACS*), which is still considered the gold standard (Ekman and Friesen 1978). The FACS is based on anatomical analysis of visible facial movements which are categorised as action units (AUs). The FACS lists 44 different AUs, each AU being based on discrete movements of specific muscles.

FACS analyses of facial expressions are not carried out in real time, but instead the videotaped facial expressions are coded in slow-motion and stop-frame feedback, thus making the coding very time-consuming and not suitable for use in clinical settings. For research purposes, however, the FACS has enabled us to better describe and understand facial responses occurring during the experience of pain. Another method to analyse facial responses is the electromyogram (*EMG*). However, so far, very few studies have used facial EMG to assess facial responses to pain (Mailhot et al. 2012; Wolf et al. 2005) because despite EMG being able to pick up even subtle muscle activities, only a limited number of facial muscles can be assessed simultaneously. Moreover, the ability to isolate a facial muscle is much poorer when using surface EMG (due to *EMG crosstalk* amongst neighbouring muscles) compared to FACS analyses (Hess 2009). Apart from FACS and EMG analyses, new developments in visual computer techniques have rendered the possibility of developing *automated recognition systems* for facial expressions of pain. Several attempts in this direction have been made (e.g. Bartlett et al. 2014; Hammal et al. 2008). However, the development is still at its beginning and not ready to be used in clinical or most research contexts. The most important shortcoming so far has been that the majority of attempts to develop automatic recognition systems for facial pain displays have used video material with posed facial expressions that depict prototypical "caricatures" of pain expressions that lack naturally occurring variations (only intensified pain-prototypical facial expressions are shown). However, in order for such a system to validly decode actual pain displays, it is crucial that such a system is capable to detect pain despite the occurrence of variations in facial displays. Nevertheless, the developments in this area are promising and might render an automatic analysis of facial responses to pain possible in the next decades.

8.2.2 What Do Facial Expressions of Pain Look Like?

It is acknowledged that facial responses to pain are not unspecific grimacing but convey pain specific information (Hadjistavropoulos et al. 2011; Williams 2002). There seems to be a subset of facial movements that repeatedly occur across different types of pain (ranging from different types of experimental pain induction procedures to clinical pain (Prkachin 1992; Prkachin and Solomon 2008)) as well as across individuals (male/female (Kunz et al. 2006); young/old (Kunz et al. 2008b)). This subset includes as the most prominent facial movements: tightening of the muscles surrounding the eyes, furrowed brows, raising the upper lip/nose wrinkling and eye closure (Prkachin 1992; Prkachin and Solomon 2008). In addition, opening of the mouth has also been frequently observed (Craig et al. 2011). Images of these facial movements are displayed in Fig. 8.1. The combination of these facial movements is often referred to as the "prototypical facial expression of pain".

It is, however, important to keep in mind that despite the evidence that these key facial activities reliably occur during pain, this does not imply only one uniform facial expression of pain that can be observed at all times and in all individuals (Craig et al.

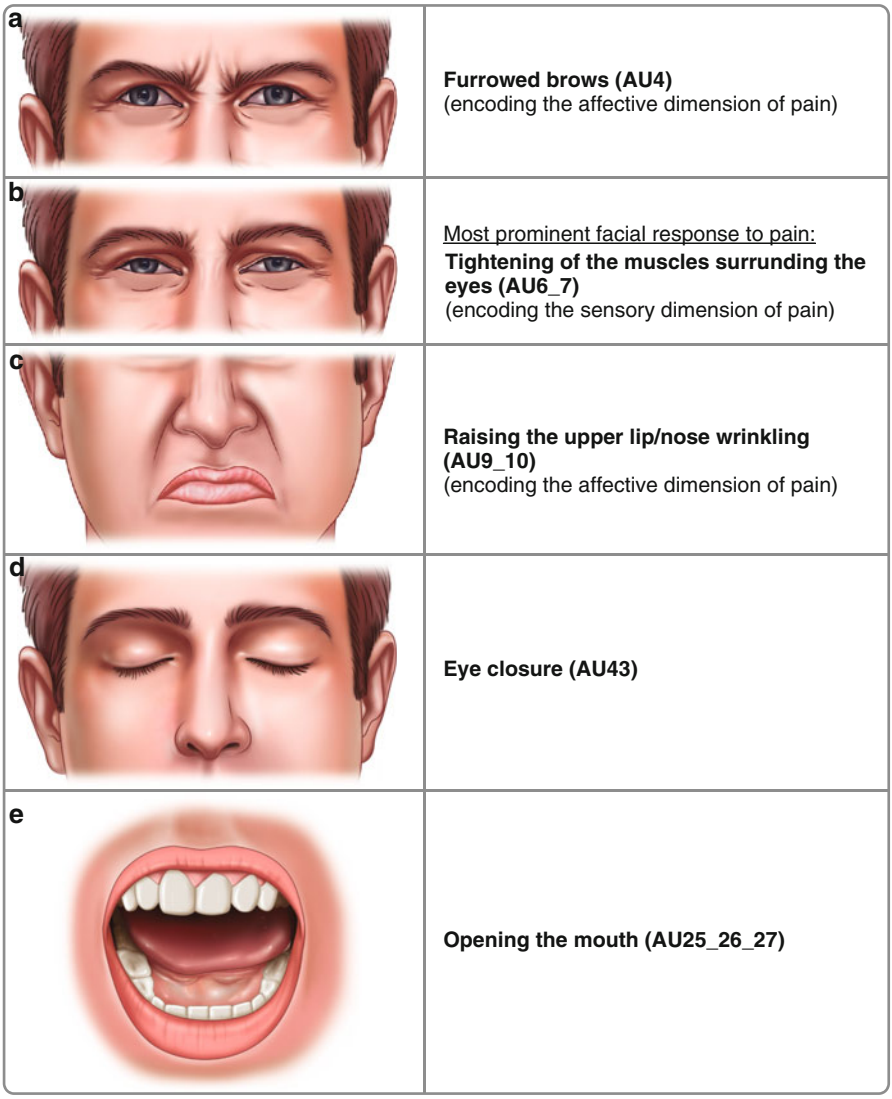

Fig. 8.1 (**a**–**e**) Pain-indicative facial movements: shown are those facial movements that are frequently displayed in the context of experimental as well as clinical pain conditions. Facial responses to pain have mostly been analysed using the FACS which categorises facial responses in different action units (AUs). Each picture illustrates a different AU that has been found to be pain indicative

2011). Instead, the frequencies of occurrence of these key movements during pain usually range from 10 to 60 % (Kunz et al. 2011a, b; Kunz and Lautenbacher 2014). Therefore, the likelihood that all four key facial movements occur simultaneously or in other words the likelihood that an individual displays the complete "prototypical

expression of pain" is very low. Rather, individuals often display only parts of this subset, sometimes even blending it with a limited range of other facial activities (e.g. smiling; Hale and Hadjistavropoulos 1997; Kunz et al. 2009, 2013a, b). Recently it has been shown that it is more helpful to differentiate between at least three different facial activity patterns of pain that are displayed in the context of pain and which are composed of different combinations of facial movements (Kunz and Lautenbacher 2014). These were as follows: (a) tightening of the muscles surrounding the eyes with furrowed brows and wrinkled nose (pattern I, combination of A + B + C of Fig. 8.1), (b) furrowed brows with tightening of the muscles surrounding the eyes (pattern II; combination of A + B of Fig. 8.1) and (c) opened mouth with tightening of the muscles surrounding the eyes (pattern III; combination of B + D of Fig. 8.1).

These different facial activity patterns all have one facial movement in common, namely, the tightening of the muscles surrounding the eyes (AU 6_7). This facial movement is indeed the most frequent and, thus, possibly the most important marker that occurs during pain (Craig et al. 2011). Interestingly, this facial movement encodes the sensory dimension of pain (giving information on the intensity of pain) (Kunz et al. 2012b) and perhaps the information on the sensory dimension of pain might be the most important aspect that needs to be communicated to onlookers (in order to warn them for potential danger). In contrast, furrowed brows and wrinkled nose – encoding the affective dimension of pain (Kunz et al. 2012b) – occur much less frequently. Thus, facial expressions of pain are a multidimensional response system, encoding the sensory aspects as well as the affective dimensions of pain, however, with an emphasis on the sensory aspects.

It is also important to mention that a considerable percentage of individuals (approximately 15–25 %) do not show any visible facial responses during the experience of pain, although they do report moderate to even strong pain intensities (Kunz and Lautenbacher 2014). This is especially true for chronic pain patients, since chronic or long-lasting pain is most often not accompanied by facial expressions of pain. Only if there is an acute exacerbation of pain, facial expressions will be elicited. For example, a patient with chronic back pain might experience constant pain of moderate intensity while he/she is sitting at a table for an hour, and this constant pain level will likely not be accompanied by facial expressions. However, if the patient gets up, the moderate pain might increase to a strong intensity and this exacerbation will elicit facial expressions of pain. It is important to keep in mind that that a "stoic face" is not necessarily incompatible with the experience of pain and individuals might be experiencing pain although they do not show any pain-related facial activity (Craig et al. 2011; Kunz and Lautenbacher 2014).

8.3 Body Postures/Movements

Although it is unquestionable that the experience of pain is typically accompanied by body postures/movements, little research has been conducted so far that aimed at classifying or describing body movements accompanying pain using objective

assessment tools. Reasons for the lack of research might stem from the complexity and variability of bodily movements and the lack of instruments to objectively assess them. Moreover, given that body movements are believed to have a primary pain management and not a primary communicative function (Prkachin 1986), they do not need to be as distinct or as definable as facial expressions. Given that the origin of pain, the quality of pain, and the body areas/body parts being affected can vary immensely, body movements aiming at reducing or controlling the pain can also be expected to vary immensely. Nevertheless, despite this enormous diversity, there seem to be some body postures/movements that have repeatedly been observed across different types of pain and that might be pain indicative for various types of pain. These body movements are guarding (abnormally slow, stiff, interrupted or rigid movement), bracing (a stiff, static position) and rubbing the painful area (Labus et al. 2003).

8.4 Paralinguistic Vocalisation

So far, even less is known about vocalisation changes occurring during pain. Although it is acknowledged that pain experiences are accompanied by paralinguistic vocalisations – such as crying, shouting, groaning – studies are lacking that have tried to investigate these pain-indicative vocalisations using specialised voice analyses tools. Using voice analyses tools, the following parameters should be assessed in order to better characterise pain-indicative vocalisations: frequency, voice intensity, formants and voice quality as well as temporal characteristics (Scherer et al. 2003). Only when assessing and analysing these parameters we will be able to characterise pain-indicative vocalisations and possibly differentiate them from paralinguistic vocalisations of other types of emotional states.

8.5 Differentiating Behavioural/Facial Markers of Pain from Behavioural Responses to Other Emotions

Observers are able to differentiate behavioural markers of pain (especially facial expressions) from behavioural responses to other types of affective states (e.g. anger, joy, surprise) well above chance level (Simon et al. 2008; Kappesser and Williams 2002), and this ability to differentiate is already developed by the ages of 5–6 years (Deyo et al. 2004). Even though these findings seem promising, there are also several studies demonstrating substantial shortcomings in pain recognition (e.g. mistaking pain for disgust, underestimation of pain; Chambers et al. 1989; Kappesser et al. 2006; Kunz et al. 2013a), and compared to almost all of the six basic emotional states (anger, disgust, fear, happiness, sadness and surprise), the recognition accuracy for facial pain expressions seems to be the lowest (Simon et al. 2008; Kappesser and Williams 2002). The reasons why behavioural/facial markers

of pain can be confused with other emotions are that each single marker by itself does not exclusively occur during pain but also during other emotional states. For example, each of the single facial movements displayed in Fig. 8.1 can also be found during other emotional states, such as happiness (contraction of the muscles surrounding the eyes), during disgust (nose wrinkle) and anger (furrowed brow). Thus, none of the single facial movements by itself can differentiate between pain and other emotional states, but the combinations of facial movements, their temporal patterns and context information, as well as the combination of facial expressions, body posture and paralinguistic vocalisations help us to correctly interpret these behavioural/facial markers of pain.

Interestingly, experience with pain diagnostic and/or pain management by itself does not improve the ability to correctly infer pain from facial expressions (e.g. Lautenbacher et al. 2013); however, a training procedure specifically targeting the facial expressions of pain has been shown to be successful. Solomon et al. (1997) developed such a training procedure to improve recognition accuracy for pain. Based on the finding that pain is accompanied by a specific set of facial movements (Prkachin 1992; Prkachin and Solomon 2008), observers were trained to recognise these facial movements (see Fig. 8.1 where these facial movements are displayed). And indeed, those observers who received this training showed better decoding accuracy compared to a control group (Solomon et al. 1997). Given the clinical importance of correctly interpreting behavioural/facial markers of pain, such a training seems to be a promising approach.

8.6 Impact of Cognition on Behavioural/Facial Markers of Pain

Based on empirical findings, it is acknowledged that behavioural/facial markers of pain are a mixture of biological dispositions as well as of social learning (Hadjistavropoulos et al. 2011). As for their biological dispositions, it has been shown that infants (including neonates) (Craig et al. 2011) and congenitally blind individuals (Kunz et al. 2012a) display the same patterns or the same types of facial movements in response to pain as sighted adults do (see also Fig. 8.1 for a list of the most frequent pain-indicative facial movements). These findings clearly suggest that facial expressions of pain are “hard-wired”. As regards body movements and vocalisations, empirical findings are lacking so far. Despite facial expressions of pain having been shown to be “hard-wired”, it is also acknowledged that facial responses become modifiable across early and late childhood through social learning experiences and cognitive capacities (Hadjistavropoulos et al. 2011). One very important modification relates to the degree/intensity to which we express pain via our face. Whereas young children tend to show vigorous facial expressions of pain, older children and adults seem to have learned to effectively downregulate their facial expressions of pain (Larochette et al. 2006). In line with this finding, a recent neuroimaging study demonstrated that a low degree of facial expressiveness to pain

was associated with higher activation in fronto-striatal structures (Kunz et al. 2011a). Given that these fronto-striatal structures are known to be involved in motor inhibition, this finding suggests that low expressive individuals actively suppress their facial display of pain (Kunz et al. 2011a). When trying to interpret these findings, it has been argued that individuals learn to intentionally suppress the facial display of negative affect (including pain) following culturally/socially learned "display rules". These display rules represent social norms about when, where and how one should express affective states (Ekman et al. 1969) and are learned already at a young age. Based on this theory, facially responding to pain would be the "default" that individuals learn to suppress due to social/cultural demands (e.g. "big boys don't cry", "one mustn't be oversensitive to pain"). In accordance with this theory, it has been demonstrated in previous studies that social learning and social context indeed influence the degree of facial expressiveness to pain. The presence of others can reduce (e.g. when being together with a stranger) as well as increase (when being together with a loved one) the amount of pain-indicative facial responses depending on the nature of the relationship between observer and sufferer (Karmann et al. 2014; Vervoort et al. 2008). Furthermore, it has been shown that the degree of facial expressiveness to pain can be effectively modulated by different types of learning, with operant conditioning techniques leading to an increase (positive reinforcement of facial expressions of pain) or decrease (positive reinforcement of a neutral expression) in facial expressiveness to noxious stimulation, respectively (Kunz et al. 2011b). This learned ability to mostly downregulate facial expressions of pain seems to depend on the cognitive status of the individual.

Not surprisingly, given the involvement of prefrontal structures in the inhibition of facial displays, patients with cognitive impairments (dementia) have been found to display elevated facial expressions when experiencing pain (Hadjistavropoulos et al. 2000; Kunz et al. 2007, 2008a). It is possible that facial responses to noxious stimulation are increased in patients with dementia because the cognitive ability to control the impulse to facially display their inner state is impaired in demented patients. As discussed above, we mainly learn in the course of childhood to inhibit the facial display of negative affective states, such as pain, owing to certain display rules, and this ability to suppress facial responses to pain might be impaired in patients with dementia. However, it is also possible that the increased facial responses are due to the fact that patients with dementia lose the capacity to anticipate the pain and when it will end or exercise adequate cognitive control over the pain experience.

The cognitive capacity of an individual does – however – have no impact on the types of facial markers being displayed during pain. It has been found that facial expressions occurring during pain are composed of the same types of facial movements as found in non-demented elderly individuals in response to pain (Kunz et al. 2007). These findings are very promising for clinical settings, given that they clearly suggest that the face seems to specifically encode the experience of pain and that this specific encoding does not change in the course of dementia.

The findings for body movements being affected by cognitive decline in patients with dementia might be less promising. Many researchers seem to believe body

movements/postures remain pain indicative, given that "guarding", "bracing" and "rubbing" are included in most of the observational scales for pain assessment in patients with dementia (Herr et al. 2006; Zwakhalen et al. 2006). Nevertheless, some authors have issued the concern that these body movements might be less discriminant in frail elderly patients with dementia (Weiner et al. 1999). Indeed, elderly patients with dementia may have difficulties in moving or may show stiffness due to arthritis or due to Parkinson's disease, and therefore, these changes in body movements might be completely unrelated to pain per se. This could mean that pain can be wrongly diagnosed even though the patient is pain-free (and is "only" functionally impaired) or that pain is overlooked because health-care professionals interpret these behaviours simply as age-related impairments (Weiner et al. 1999). More research is needed in this area.

8.7 Conclusions

The experience of pain is typically accompanied by a certain set of behavioural responses including facial expressions, body postures/movements and paralinguistic vocalisations. These behavioural markers are of great clinical relevance, especially in cognitively unimpaired individuals and infants who are not able to provide self-report of pain. Consequently, pain becomes what the observer/health-care professional/caregiver/parents decides it is. Such a decision is usually based on the individuals' behaviour responses.

So far, research has mainly focused on facial expressions of pain. Here, some key facial movements have been described that occur frequently in the context of pain (see Fig. 8.1). These movements are rather seldom displayed together simultaneously when individuals are experiencing pain, but instead individuals most often show different combinations of these single facial movements. Most frequently, tightening of the muscles surrounding the eyes is paired with one or two of these other pain-indicative responses. These movements are also able to encode different aspects of pain, with the eyes primarily encoding the sensory dimension whereas the eyebrows and nose movements encoded the unpleasantness of pain. With regard to body movements and vocalisations occurring during the experience of pain, objective and reliable descriptors are mostly lacking so far but are urgently needed.

References

Bartlett MS, Littlewort GC, Frank MG, Lee K (2014) Automatic decoding of facial movements reveals deceptive pain expressions. Curr Biol 24:738–743

Chambers CT, Reid GJ, Craig KD, McGrath PJ, Finley GA (1989) Agreement between child and parent reports of pain. Clin J Pain 14:336–342

Craig KD, Versloot J, Goubert L, Vervoort T, Crombez G (2010) Perceiving pain in others: automatic and controlled mechanisms. J Pain 11:101–108

Craig KD, Prkachin KM, Grunau RVE (2011) The facial expression of pain. In: Turk DC, Melzack R (eds) Handbook of pain assessment, 3rd edn. Guilford, New York, pp 117–133
Deyo KS, Prkachin KM, Mercer SR (2004) Development of sensitivity to facial expression of pain. Pain 107:16–21
Ekman PE, Friesen WV (1978) Facial action coding system. Consulting Psychologists Press, Palo Alto
Ekman PE, Sorenson ER, Friesen WV (1969) Pan-cultural elements in facial displays of emotions. Science 164:86–88
Hadjistavropoulos T, LaChapelle DL, MacLeod FK, Snider B, Craig KD (2000) Measuring movement-exacerbated pain in cognitively impaired frail elders. Clin J Pain 16:54–63
Hadjistavropoulos T, Craig KD, Duck S, Cano A, Goubert L, Jackson PL, Mogil JS, Rainville P, Sullivan MJ, de C Williams AC, Vervoort T, Fitzgerald TD (2011) A biopsychosocial formulation of pain communication. Psychol Bull 137:910–939
Hale C, Hadjistavropoulos T (1997) Emotional components of pain. Pain Res Manag 2:217–225
Hammal Z, Kunz M, Arguin M, Gosselin F (2008) Spontaneous pain expression recognition in video sequences. In: Proceedings of BCS international academic conference – visions computer science, pp 191–210
Herr K, Bjoro K, Decker S (2006) Tools for assessment of pain in nonverbal older adults with dementia: a state-of-the-science review. J Pain Symptom Manage 31:170–192
Hess U (2009) Facial EMG. In: Harmon-Jones E, Beer JS (eds) Methods in social neuroscience. Guilford Press, New York, pp 70–91
Kappesser J, Williams AC (2002) Pain and negative emotions in the face: judgements by health care professionals. Pain 99:197–206
Kappesser J, Williams AC, Prkachin KM (2006) Testing two accounts of pain underestimation. Pain 124:109–116
Karmann AJ, Lautenbacher S, Bauer F, Kunz M (2014) The influence of communicative relations on facial responses to pain: does it matter who is watching? Pain Res Manag 19:15–22
Kunz M, Lautenbacher S (2014) The faces of pain: a cluster analysis of individual differences in facial activity patterns of pain. Eur J Pain 18(6):813–823
Kunz M, Gruber A, Lautenbacher S (2006) Sex differences in facial encoding of pain. J Pain 7:915–928
Kunz M, Scharmann S, Hemmeter U, Schepelmann K, Lautenbacher S (2007) The facial expression of pain in patients with dementia. Pain 133:221–228
Kunz M, Mylius V, Scharmann S, Schepelman K, Lautenbacher S (2008a) Influence of dementia on multiple components of pain. Eur J Pain 13:317–325
Kunz M, Mylius V, Schepelmann K, Lautenbacher S (2008b) Impact of age on the facial expression of pain. J Psychosom Res 64:311–318
Kunz M, Prkachin K, Lautenbacher S (2009) The smile of pain. Pain 145:273–275
Kunz M, Chen JI, Lautenbacher S, Vachon-Presseau E, Rainville P (2011a) Cerebral regulation of facial expressions of pain. J Neurosci 31:8730–8738
Kunz M, Rainville P, Lautenbacher S (2011b) Operant conditioning of facial displays of pain. Psychosom Med 73:422–431
Kunz M, Faltermeir N, Lautenbacher S (2012a) Impact of visual learning on facial expressions of physical distress: a study on voluntary and evoked expressions of pain in congenitally blind and sighted individuals. Biol Psychol 89:467–476
Kunz M, Lautenbacher S, Leblanc N, Rainville P (2012b) Are both the sensory and the affective dimensions of pain encoded in the face? Pain 153:350–358
Kunz M, Peter J, Huster S, Lautenbacher S (2013a) Pain and disgust: the facial signaling of two aversive bodily experiences. PLoS One 8:e83277
Kunz M, Prkachin K, Lautenbacher S (2013b) Smiling in pain: explorations of its social motives. Pain Res Treat Article ID 128093
Labus JS, Keefe FJ, Jensen MP (2003) Self-reports of pain intensity and direct observations of pain behavior: when are they correlated? Pain 102:109–124

Larochette AC, Chambers CT, Craig KD (2006) Genuine, suppressed and faked facial expressions of pain in children. Pain 126:64–71

Lautenbacher S, Niewelt BG, Kunz M (2013) Decoding pain from the facial display of patients with dementia: a comparison of professional and nonprofessional observers. Pain Med 14:469–477

Mailhot J-P, Vachon-Presseau E, Jackson PL, Rainville P (2012) Dispositional empathy modulates vicarious effects of dynamic pain expressions on spinal nociception, facial responses and acute pain. Eur J Neurosci 35:271–278

Prkachin KM (1986) Pain behavior is not unitary. Behav Brain Sci 9:754–755

Prkachin KM (1992) The consistency of facial expressions of pain: a comparison across modalities. Pain 51:297–306

Prkachin KM, Solomon PE (2008) The structure, reliability and validity of pain expression: evidence from patients with shoulder pain. Pain 139:267–274

Scherer KR, Johnstone T, Klasmeyer G (2003) Vocal expression of emotion. In: Davidson R, Scherer KR, Goldsmith H (eds) Handbook of the affective sciences. Oxford University Press, New York, pp 433–456

Simon D, Craig KD, Gosselin F, Belin P, Rainville P (2008) Recognition and discrimination of prototypical dynamic expressions of pain and emotions. Pain 135:55–64

Solomon PE, Prkachin KM, Farewell V (1997) Enhancing sensitivity to facial expressions of pain. Pain 71:279–284

Vervoort T, Goubert L, Eccleston C, Verhoeven K, De Clerq A, Buysse A, Crombez G (2008) The effects of parental presence upon the facial expression of pain: the moderating role of child catastrophizing. Pain 138:277–285

Weiner D, Peterson B, Keefe F (1999) Chronic pain-associated behaviors in the nursing home: resident versus caregiver perceptions. Pain 80:577–588

Williams AC (2002) Facial expression of pain: an evolutionary account. Behav Brain Sci 25:439–455

Wolf K, Mass R, Kiefer F, Naber D, Wiedemann K (2005) The face of pain – a pilot study to validate the measurement of facial pain expression with an improved electromyogram method. Pain Res Manag 10:15–19

Zwakhalen SM, Hamers JP, Abu-Saad HH, Berger MP (2006) Pain in elderly people with severe dementia: a systematic review of behavioural pain assessment tools. BMC Geriatr 6:3