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The facial expression of pain in humans considered from a social perspective

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The social modulation of pain in humans has been neglected so far with respect to verbal as well as non-verbal communication of pain. The facial pain expression is a powerful way to communicate pain, and there are some theoretical accounts available on how social modulation may affect the encoding of the facial expression of pain. Some accounts, particularly in the pain field, are proximate explanations on the mechanisms involved, whereas an evolutionary psychology account takes a more comprehensive approach. A review of nine experimental studies revealed that in the majority of studies (6/9), social context had an effect on the facial pain expression, but results were inconsistent. Several conceptual and methodological issues are discussed which may explain these inconsistencies and could help in design of future experimental studies.

This article is part of the Theo Murphy meeting issue 'Evolution of mechanisms and behaviour important for pain'.

1. Introduction

Pain is defined as a highly subjective experience [1], yet, it can be communicated to the social environment by what Fordyce [2,3] called 'pain behaviours'. Usually, pain behaviours are classified into verbal pain behaviours such as exclaiming, reporting or describing pain and non-verbal pain behaviours such as vocalizations, facial expressions, body movements or physiological changes [4]. Pain behaviours are commonly considered to serve either a communicative function, such as self-report or facial expression, or a protective function, such as limping [5].

2. The facial expression of pain

Facial expressions are a powerful social communication[1] and have been studied for several decades in humans [4,9,10]. Pain research has mainly used methods developed in emotion research such as the Facial Action Coding System (FACS; [11,12]), enabling trained researchers to code over 40 distinct muscle movements. Prototypical movements, the so-called Action Units, were found by some research groups, not only for what are regarded as 'basic emotions', such as happiness, anger, sadness, surprise, fear and disgust ([13]; for a critical view of the concept of basic emotions, see e.g. [14]). Prototypical facial movements were also found for further emotional experiences, including pain [15]. A facial expression of pain in humans is characterized by lowering of the eyebrows, squeezing of the eyes, wrinkling of the nose, raising of the upper lip and opening of the mouth [4]. Observers of human pain facial expressions were able to reliably distinguish pain from a variety of other facial expressions [15–17]. In humans, this pain face is consistently displayed across ages in experimental as well as clinical settings [15]. Despite some differences between humans and other mammals, pain-related facial expressions have also been identified in rodents, rabbits, cats and horses [18–22].

3. Impact of social context on pain communication

In contrast to cognitive and affective modulation of pain, social modulation has been largely neglected in pain research [23,24], despite the potential of a better

understanding of social modulation to improve pain treatments [24] and 'a plethora of clinical, correlational findings pointing to associations between pain and the social context in which it occurs' [23, p. 1]. Accordingly, there are only a few theories applicable to the social modulation of facial expressions of pain. This is different with regard to the decoding of facial expressions of pain by observers and their resulting actions, where there are many more theoretical approaches available, some of which have also been tested already (e.g. social contract theory, see [25–28]).

The Social Communication Model of Pain (SCMP; [29–31]) provides a useful framework for considering, organizing and integrating biological, psychological and social dimensions and their dynamic interplay in the way in which pain is communicated, i.e. experienced, encoded and expressed by the person in pain and decoded by the onlooker.

Of the theories available to explain in which social context pain is (not) expressed facially, some stem from the pain field and are proximate explanations of the mechanisms involved; one stems from evolutionary psychology and takes a more comprehensive approach as it offers an explanation of the function of behaviours that have been shaped by natural selection as they were advantageous for individuals who used them [15,32].

(a) An evolutionary approach to encoding of facial pain expressions in a social context

With regard to facial expressions, emotion researchers introduced the concept of 'display rules', which are 'cultural norms governing the regulation of expressive behaviour depending on social contexts' [33, p. 1], and determine when, where and to what extent emotions are expressed. They have so far, however, only been researched at a population level, such as in studies on inter-ethnic differences [34]. Yet, there are some studies in the pain literature that investigate some possible modes of expression: expression without modification, amplification or inhibition, concealment, neutralization, combined expression of emotions and simulation [35–37].

Evolutionary psychologists make use of the concept of specific facial expressions as assumed by Ekman [9,13] as well as display rules [38], and assume that pain is expressed in the presence of supporting others and suppressed in the presence of adversaries, in order to elicit help from supporting others and to avoid showing vulnerability to adversaries. As the unmodulated facial expression serves no apparent protective function, it is generally assumed to serve only a communicative function. Evolutionary psychologists hold that communication systems require rules on whether the system should transmit information or not. When over evolutionary time it was on average beneficial to share an emotional state (I am in pain.) and convey information on risk (Someone/something in the environment hurt me.) to conspecifics nearby, species-typical facial and other expressions of emotions were selected [38]. Among the factors affecting whether a particular emotion should be expressed in a particular situation or not are: (1) the information that the particular emotion would reveal and (2) the relationship between displayer and observer [38]. In such a framework, expressing pain facially provides information to those close by on a possible proximate danger to them and might elicit their help. However, potential competitors could take advantage of the pain displayer's vulnerability. Therefore, it is more advantageous to share the information on the internal state 'pain' with cooperators rather than with adversaries. Such assumptions can be simulated in artificial life experiments in which complex behaviours in combination with environmental pressures can be modelled over evolutionarily relevant time spans (e.g. [39]).

(b) Theoretical approaches in the pain field to encoding of facial pain expressions in a social context

Several theoretical approaches regarding the social modulation of the encoding of the pain facial expression can be found in the pain literature: one stresses the impact of a pain-specific personality trait (Communal Coping Model, CCM) and one stresses affective states (Cognitive Appraisal Model, CAM).

The CCM [40–42] is the most explicit theoretical account in the pain research field of the effect of social context on the encoding of the facial expression of pain. It assumes that individuals interpret pain differently depending on their trait to catastrophize about pain. Individuals who tend to catastrophize about pain feel particularly vulnerable when in pain and seek help from others by communicating their pain verbally and facially. Such 'pain catastrophizers', therefore, display facial pain particularly in the presence of other people, rather than in relation to the pain stimulus, i.e. every pain stimulus is appraised as threatening and, therefore, pain is expressed facially in the presence of other people, independently of the relation to the other person (e.g. partner versus stranger), as they may provide support. Despite its major impact on pain research and treatment, the conceptualization of pain catastrophizing as a trait has been questioned (e.g. [43]).

The CAM [44–47] proposes that pain stimuli vary in the level of threat they elicit. Pain stimuli perceived as threatening elicit pain-related fear and facial expressiveness of pain. The CAM assumes that if the perceived threat of pain is high, certain social contexts such as the presence of another individual could provide a safety signal to the person in pain, thereby reducing the threat value of pain and, accordingly, pain-related fear and facial expressiveness of pain. The CAM, however, makes no specific predictions in terms of which social contexts serve as safety signals. The recent Free Energy Framework (FEF; [23]) is more specific in stating that the social context can signal either safety or threat in relation to the pain stimulus itself or to the environment in which the pain stimulus occurs. However, the CAM as well as the FEF seem hard to operationalize since their predictions depend heavily not only on individuals' perceptions of a pain stimulus as (not) threatening but also on their perceptions of certain social contexts as safety or threat signals.

(c) Empirical evidence for the social modulation of pain facial expressions

For their systematic review, Krahé and colleagues [23] collected all available studies in which the impact of social modulation on pain had been investigated experimentally. Among these studies are seven using pain facial expressions as an outcome (table 1). The review by Krahé *et al*. [23] included a study by Kleck *et al*. [59] which is excluded here

Table 1. Effects of social context on facial communication of pain: a summary of experimental studies (adapted from [23]).

reference	exp. design	sample	social partner	social context manipulation	pain induction technique	facial expression measure	results
[48]	between-subject design	120 healthy children aged 8–12 (60 girls)	mother	maternal behaviour during pain (1) pain promoting (2) pain reducing (3) neutral interaction	cold pressor test (left hand, 10°C, maximum 4 min)	Child Facial Coding System [49,50]; five items[a]; 10 s segments	no main effect of social context
[51]	within-subject design	63 heterosexual couples	partner, stranger (experimenter)	presence of another person (1) partner (2) stranger (3) alone	10 heat stimuli in each condition (left lower leg; 5 s; 3°C above threshold)	FACS [11,12]; 5 s segments; presence and intensity	significant main effect of social context (higher expression in the presence of the partner compared with the presence of the experimenter or being alone)
[52]	between-subject design	70 healthy women (most students)	female stranger (confederate)	confederate's behaviour causing (1) high social threat (2) low social threat	10 electric stimuli (right ankle; 600 ms, individually calibrated to be 8/10 on a 0–10 NRS)	Child Facial Coding System [49,50]; 6 items[b]; 1 s segment	no main effect of social context or interaction social context × catastrophizing
[53]	within-subject design	32 healthy women (most students)	two female strangers (confederates)	confederates' behaviours causing (1) high social threat (2) low social threat	10 electric stimuli in each condition (right ankle; 3 s, individually calibrated to be moderately painful)	Child Facial Coding System ([49,50]; six items[b]; 1 s segment	significant main effect of social context (lower expression in the high rather than in the low social threat condition)
[54]	between-subject design	67 healthy participants (49 women)	female stranger (confederate)	confederate's behaviour causing (1) high social threat (2) low social threat (3) no social threat	five electric stimuli (inside of wrist; 3 s; individually calibrated to be 8/10 on a 0–10 NRS)	Child Facial Coding System [49,50]; six items[b]; 1 s segment; intensity	significant main effect of social context (lower expression in the high rather than the low and no social threat condition)
[55]	between-subject design	64 healthy students (38 women)	stranger	presence of another person during pain (1) alone (2) observer	cold pressor test (non-dominant arm, 2°C, fixed 1 min interval)	global facial pain expression[c] [63]; 10 s segment; presence and duration	interaction social context × catastrophizing (those who score high on pain catastrophizing show facial expressions longer when an observer is present than when alone; no effect of social context for low scorers)

(*Continued*.)

Table 1. (*Continued.*)

reference	exp. design	sample	social partner	social context manipulation	pain induction technique	facial expression measure	results
[56]	between-subject design	84 healthy children aged 9–15 (44 girls)	parent, stranger	presence of another person during pain (1) parent (2) stranger	pressure (neck, shoulder; 70 kg m^{-2} above threshold)	Child Facial Coding System [49,50]; 13 items (10 intensity, 3 presence)[e]; during and 5 s after pressure	no effect of social context; main effect of pressure intensity (higher pressure leads to higher expression)
[57]	within-subject design	38 healthy children aged 10–18 (16 girls)	parent	presence of another person during pain (a) alone (b) parent	cold pressor test (left hand, 12°C, fixed 1 min interval)	Child Facial Coding System [49,50]; 13 items (10 intensity, 3 presence)[d]; 10 s interval during immersion	interaction of social context and child catastrophizing (low scoring children expressed more when observed by parent than when alone; high scoring children expressed increased pain independent of context)
[58]	between-subject design	149 healthy participants (88 women)	stranger	presence of another person during pain (a) stranger (b) alone	cold pressor test (2–4°C, fixed 1 min immersion time)	Child Facial Coding System [49,50]; 13 items (10 intensity, 3 presence)[d]; 6 × 10 s intervals during, 6 × 10 s after immersion	interaction of social context and threat (in the absence of threat no effect of social context; more pain is expressed when alone in the threat context)

[a]Five items of Child Facial Coding System (CFCS) indicative of pain: brow lower, eye squeeze, cheek raise, nose wrinkle, upper lip raise.

[b]Six items of CFCS indicative of pain: brow lower, eye squeeze, eye squint, cheek raise, nose wrinkle, upper lip raise.

[c]For the purposes of the present coding system, the Pain Grimace was coded as 'present' if one or more of the following facial movements were detected: (a) brow lowering, (b) narrowing of the eye lids, (c) cheek raising, (d) nose wrinkling, (e) upper lip raising, (f) closing of the eyelids.

[d]M. J. L. Sullivan, H. Adams, M. O. Martel, P. Thibault, T. Vervoort, H. Butler. Pain Behaviour Coding Manual. Pain(t) Can Paradigm. Unpublished manual. Details on request from the first author.

[e]All items of CFCS indicative of pain: brow lower, squint, eye squeeze, nose wrinkle, nasolabial furrow, cheek raise, upper lip raise, lip corner pull, vertical mouth stretch, horizontal mouth stretch, blink, nostril flare, open lips.

since the facial pain expression was rated for distress on an analogue scale and no coding system like the FACS has been applied. Further, three studies published since have been added [51–53], providing the nine studies included in table 1.

What conclusions can be drawn from table 1? One important result is that the effects of social context on facial expressions of pain are inconsistent. Of nine studies, three found no (main or interaction) effect of social context on facial expressions of pain [48,52,56]. Although six of nine studies found significant effects, direction was inconsistent. One study showing a main effect of social context revealed that facial expressions of pain were more frequently displayed in the presence of the participant's partner than of a stranger or alone [51]. Another study that similarly varied social context (the presence of stranger versus parent) found no effect of social context [56]. Two other studies finding a main effect of social context revealed that less facial expression was shown when a stranger behaved threateningly rather than unthreateningly [53,54], but another study from the same research group could not replicate the effect [52]. Two studies found an interaction between catastrophizing and social context, but the form of the interaction was not consistent: whereas the study by Sullivan and co-workers [42] found that social context (stranger versus alone) did not affect participants scoring low in catastrophizing, participants scoring high displayed facial pain expressions longer when observed than when alone. The study by Vervoort *et al*. [57], on the other hand, found that social context (parent versus alone) did not affect participants scoring high in catastrophizing. Low scoring catastrophizing participants expressed their pain more frequently when observed by their parents. Other studies including catastrophizing found no interactions with social context [54,58]. Social context also interacted with the threat value of pain [58]: more pain was facially expressed when participants were alone in the threat condition rather than in the presence of a stranger. In the absence of pain threat, social context (stranger versus alone) had no effect on the facial expression of pain.

4. Drawing conclusions from the empirical evidence

Undoubtedly the small number of studies contributes to the inconsistency of results. In the process of reviewing, however, some aspects became apparent that may help to clarify and improve theoretical accounts and/or experimental studies. The first point is that the way in which social context is operationalized in the experimental studies varies very considerably. Experimental manipulations range from the mere presence of other individuals to specific behaviour of the social partner to engender threat or to reinforce participants' pain. As a construct, 'social context' is broad and lacks a convincing and acknowledged definition; hence any attempt to define social context top-down by breaking it down into different aspects that would be easier to operationalize would be a valuable first step. This process may be accomplished by a bottom-up collection and comparison of available operationalizations, a process that could draw on reviews such as that by Krahé *et al*. [23].

In addition to working towards a definition of social context, research could usefully draw more on theoretical accounts. Eight of the nine experimental studies reviewed above referred in their introduction to one of the theoretical approaches or explicitly set out to examine one. Some authors referred to several but only when discussing their results. Only one study explicitly set out to test the predictions of two available theoretical accounts (CCM and CAM) against each other [58]; this approach is likely to be productive. Future studies should help to establish experimental designs in which the threat value of pain is systematically and successfully manipulated. Accordingly, more experimental designs are needed in which the social context exceeds the mere presence or the absence of neutral observers or partners, such as in the studies by Vlaeyen and co-workers [52–54], where experimental situations were created causing threat. Moreover, differences in pain facial expression between threatening pain stimuli and threatening social contexts need investigation.

For the evolutionary approach, some existing specific hypotheses or assumptions have not yet been tested, such as the assumption that facial expressions of pain serve a communicative purpose, or the hypothesis, elegantly outlined by Williams [15]. What an operant framework would consider as exaggeration of pain facial expression could, from an evolutionary perspective, be formulated as a release of suppression. Yet, empirical investigations of these assumptions are still lacking. Moreover, a broader consideration of evolutionary processes would be useful not only to frame hypotheses that could then be tested empirically using experimental designs as well as simulation studies but also to provide a framework across research areas [32].

Beyond empirical investigations, many of the theoretical accounts need elaboration. The conceptualization of pain catastrophizing as a trait has been criticized [43], the CAM and the FEF need clarification of circumstances in which pain stimuli and/or the (social) environment in which pain occurs are perceived as safety signal or as threat. Also the basic emotion work based on Ekman [13] deserves further examination [14].

Further, some methodological aspects need consideration. People differ in their facial expressiveness depending on their awareness of being videotaped [60], so all studies using facial expression as an outcome should report whether their participants were aware of being videotaped. Furthermore, results may differ depending on which coding system was used, since most use the presence and intensity of muscle movements, yet differ in which muscle movements they consider and whether they combine two or more into single units, while others code the duration of the movements rather than the presence and intensity. If possible, it is ideal to blind coders to study aims since this may impact on their coding. Lastly, a substantial minority of participants are regularly found in experimental studies to display no facial expressions at all [61], possibly owing to comparatively weak stimulus intensities in experimental settings, and a wide variation in the threshold at which individuals express their pain facially [62].

The ecological validity of experimental studies raises another methodological consideration. Being able to systematically vary the threat value of pain by information given about the pain stimulus or by varying the behaviour of confederates is crucial for testing the CAM or the evolutionary psychology perspective, for example. Yet the increase in threat by experimental manipulation is often only weak [58], inevitably so given that (mostly student) participants know that experiments are conducted in highly controlled environments and observe ethical constraints. One possibility

would be to replicate studies that worked well in healthy student populations with chronic pain patients for whom the situation in the laboratory is presumably more threatening and for whom the pain experience itself would also be more threatening.

Guidance available in the conceptual and adaptive/evolutionary frameworks described above, as well as recognition of the methodological limitations of the studies to date, would help not only to explain inconsistent experimental findings but also to improve the design of future investigations into the social modulation of pain in humans.

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Endnote

[1]In addition to a social communicative perspective, there are further perspectives under which facial expressions are examined. One is a sensory regulation perspective in which facial movements prototypical for certain emotions are investigated with regard to their augmenting or diminishing sensory exposure. The facial expression of fear, for example, was found to increase the visual field as well as the volume and speed of respiratory inspirations. The facial expression of disgust, on the contrary, was found to decrease both (e.g. [6,7]). There is also an evolutionary psychology perspective investigating why certain facial movements were selected. From this viewpoint, the facial expression of anger, for example, evolved to increase the strength attributed by onlookers to the individual expressing anger. Accordingly, increasing each muscle movement's intensity was found to lead to an increase in attributed strength by onlookers (e.g. [8]).

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