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Topical review

The smile of pain

Miriam Kunz [a,b,*], Kenneth Prkachin [c], Stefan Lautenbacher [a]

[a] Physiological Psychology, Otto-Friedrich University Bamberg, Markuspl. 3, 96045 Bamberg, Germany
[b] Department of Stomatology and Centre de Recherche de l'Institut Universitaire de Geriatrie de Montreal, Universite de Montreal, Canada
[c] Department of Psychology, University of Northern British Columbia, Canada

The facial expression of pain has recently attracted considerable interest in experimental and clinical research based on an increasing awareness that it supports the communication of pain as a second signal system besides the verbal one [5,11]. In line with this, facial activity provides the possibility to develop pain assessment tools in individuals with limited abilities to communicate pain verbally (e.g. newborns, individuals with pronounced cognitive impairments and dementia [18,20,21,25]).

An early and very important observation as regards facial responses associated with pain, was that there is a subset of key facial muscle movements that are displayed consistently across different pain modalities [27]. This subset of pain-relevant facial responses includes brow lowering, orbit tightening, levator contraction and eye closure [27,29]. Although there is convergent evidence that these facial responses constitute the core of the "pain face", there are also other facial muscle movements that have frequently been observed in the context of pain. The most unexpected accompaniment of pain is the oblique raising of the lip, a facial muscle movement that is caused by contraction of the zygomatic major muscle. Ordinarily, this facial movement is seen when a person is smiling and it is assumed to be associated with happiness or positive affect [8,9]. Therefore, it is surprising that in the majority of the studies on facial responses during pain an increased frequency of oblique lip raise has been found compared to that of baseline conditions. This observation has been made regardless of whether pain was induced experimentally in pain-free individuals (cold pressor task [4,19,27], thermal heat pain [14,15], pressure stimulation [16,17,27], electrical current [17,24,26,27]) or whether clinical pain conditions were investigated (e.g. patients with shoulder or knee pathologies undergoing physiotherapy [3,11,28,29])[1]. Moreover, the percentage of individuals displaying "smiles" during painful stimulation is rather high. To illustrate this, we computed the percentage of subjects that showed oblique lip raise at least once during phasic or tonic noxious stimulation in previous studies of ours. As can be seen in Table 1, this percentage varied between 22% and 57% depending on pain induction method and number/duration of painful stimulation. The occurrence of "smiles" during painful procedures was not dependent on sex, since males and females did not differ in the frequency of oblique lip raise during painful stimulation. Moreover, "smiles" seem to occur regardless of whether subjects were aware of being videotaped or whether they were unaware of being directly observed (participants were videotaped from behind a one-way screen). How can it be explained that approximately one-third of individuals facially respond with a "smile" while experiencing pain, although smiling seems to be absolutely incompatible with the experience of pain?

Ekman and Friesen [9] reported that smiles can serve diverse communicatory functions rather than simply expressing happiness – and thus one should distinguish among different types of smiles rather than treating smiles as a single class of behaviour. Communicative functions of smiling range from the intention to conceal negative emotions (where smiles are superimposed over muscular actions associated with negative emotions) to the intention to appear as if enjoyment is felt when it is not. These smiles that seem to mainly serve a communicative function have been referred to as non-Duchenne smiles [10,23]. Duchenne [7] described a type of smile that occurs spontaneously while experiencing enjoyment and which is characterized not only by the action of the zygomatic major muscle (oblique raising of the lip), but also by the action of the obicularis oculi muscle (contraction of the muscles around the eyes). This type of smile (the smile of enjoyment) has been called the Duchenne smile [10]. Non-Duchenne smiles on the other hand lack contractions of the orbicularis oculi and do not seem to express "true" happiness. Ekman and Friesen [9] described various types of non-Duchenne smiles, such as "embarrassed smiles", "masking smiles" (while experiencing negative emotions), "false smiles" (appearing as if enjoyment is felt when it is not), "anticipatory smiles" or "miserable smiles" (representing the willingness to endure unpleasant circumstances).

To which type of smile does the "smile of pain" belongs to and what is its function? In order to answer this question, it is important to look at the temporal dynamic of "smiles" during pain. It has been argued that the raising of the oblique lip might not occur as a direct response to pain but instead might be secondary to the occurrence of pain as a post-registration response [28,29]. This hypothesis might become more plausible when looking at the facial responses to phasic (5 s) experimental painful stimuli (pressure and heat stimuli) in two exemplary subjects as shown in Fig. 1. The first photo always depicts the time of stimulus onset.

* Corresponding author. Address: Physiological Psychology, Otto-Friedrich University Bamberg, Markuspl. 3, 96045 Bamberg, Germany. Tel.: +49 951 8631850; fax: +49 951 8631976.
E-mail address: miriam.kunz@uni-bamberg.de (M. Kunz).

[1] Data on facial expressions of pain so far have been only available for more acute experimental or clinical pain. Therefore, we do not know whether the "smile of pain" also occurs during the experience of chronic pain.

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Table 1
Percentage of subjects displaying oblique lip pull (AU 12) during painful experimental stimulation, separately for males and females and in all subjects.

Type of stimuli	Reference	Being aware of being observed	Number of trials	% of males	% of females	Sex difference in frequency of occurrence	% in all
Pressure stimuli	Prkachin [27]	No	1	–	–	–	22
	Kunz et al. [17]	Yes	4	50	63	$T(38) = 1.519$; $p = 0.137$	56
Electrical stimuli	Prkachin [27]	No	1	–	–	–	48
	Kunz et al. [17]	Yes	10	50	65	$T(38) = 0.378$; $p = 0.707$	57
Thermal stimulation	Kunz et al. [14], phasic	Yes	8	34	33	$T(42) = -0.159$; $p = 0.874$	34
	Prkachin [27], tonic	No	<3 min	–	–	–	42
	Kunz et al. [15], tonic	Yes	2 × 6 min	58	42	$T(22) = 0.280$; $p = 0.782$	49

As can be seen, the first facial responses displayed by both subjects (2.9 and 3.9 s after stimulus onset) comprise clearly the subset of key facial muscle movements that have been found to be associated with pain [27,29]. The oblique lip raise, however, only starts later (4.4 s after stimulus onset). There seems to be a temporal overlap of pain-indicative facial responses and smiling with the pain-indicative responses vanishing and only smiling remaining at the offset of stimulation (5 s after stimulus onset). However, these are only descriptive findings of two exemplary subjects. Although we are confident that they are representative of the majority of "smiles" being displayed during painful stimulation, statistical fine-grained analyses are necessary to corroborate the temporal dynamic of smiling during pain.

Assuming for now, that oblique lip raise does occur as a secondary response, there are two possible explanations for this phenomenon. First, smiling may communicate states or processes that are alternative or complementary to the pain experience. For example, consciousness of the intensity of one's initial pain reaction may evoke consequent amusement or embarrassment, with associated smiling [29] (social communication function). Embarrassment (an emotional state that resembles pain in the sense that it is experienced as unpleasant) has itself been reported to be associated with smiling [12]. Similarly, it may reflect display rules or represent a means of regulating the social environment. A smile in the context of a painful experience may modify the social meaning of a pain expression, conveying the message, "It's not as bad as that" or "I can take it." Second, smiling during pain might serve as a positive, self-regulatory strategy that helps individuals to dissociate from the threatening and plaguing aspects of pain (self-regulatory coping function). The latter explanation would be in line with the recent findings on the function of smiling during negative emotional experiences [1,13,14,22,32]. Ansfield [1], for example, observed individuals while they were watching videos that should induce an emotion of disgust. It was found that participants smiled more while viewing intensely disgusting videos compared to less disgusting videos. Interestingly, the more participants smiled the less negative emotional distress they reported after viewing the intensely disgusting videos [1].

It is surprising, that although smiling seems to be such a frequent accompaniment of pain, research on this topic, focussing on the precise description of this phenomenon, has been missing so far. The foregoing explanations for the occurrence of smiling during pain lend themselves readily to empirical analysis. The social communication accounts, for example, could be evaluated by manipulating the aspects of the social context in which pain is experienced (e.g. testing participants while they are alone in a room compared to being together with a significant other). The self-regulatory account could be evaluated by examining the relations between smiling and self-reports of pain. Moreover, since facial responses during pain have been shown to play an important role in communication with significant others (eliciting empathy, support or help [2,6,11,31]), it is crucial to understand the impact

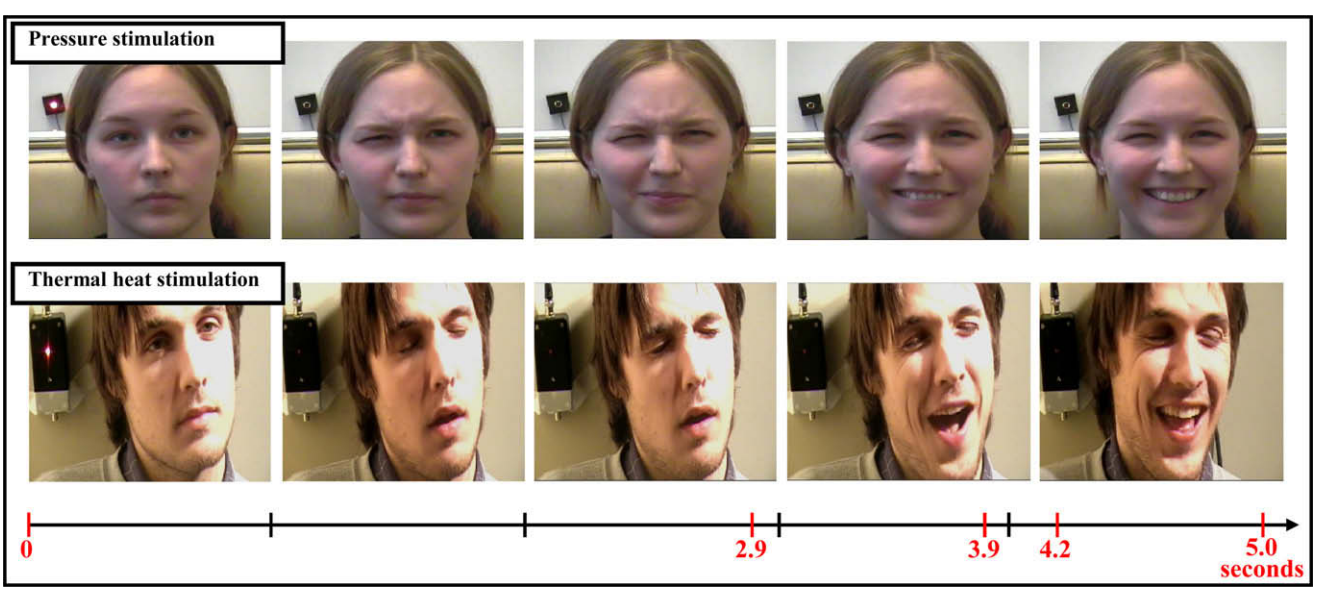

Fig. 1. Examples of facial responses to phasic (5 s) pain stimulation; with subjects displaying pain-typical responses first (1.0–3 s after stimulus onset) and later on (4.2 s after stimulus onset) displaying oblique lip raise.

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smiling has on the social perception of suffering from pain. It is entirely possible that the inference drawn by an observer can differ from or be entirely inconsistent with the message conveyed by the sufferer, a point that has been made clearly in the literature on underestimation bias [30]. Is smiling during pain considered inappropriate and does it thus decrease empathy? Or alternatively, does smiling enhance social binding when accompanying an individual under distress and does it thus increase empathy? These issues have considerable theoretical and practical importance, particularly if there is an inconsistency in the properties of the message communicated and the meaning inferred. The worst that may happen to patients at this stage of knowledge is that smiling is seen as a definite invalidation of suffering and as a signal of permission of social neglect. Therefore, more research is urgently needed to disentangle reliably the facial signals of distress and true happiness.

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