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Current Alzheimer Research, 2017, *14*, 000-000

REVIEW ARTICLE

Facial Pain Expression in Dementia: A Review of the Experimental and Clinical Evidence

Stefan Lautenbacher[a,*] and Miriam Kunz[b]

[a]*Physiological Psychology, University of Bamberg, Bamberg, Germany;* [b]*Department of General Practice, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands*

ARTICLE HISTORY

Received: January 12, 2016
Revised: May 20, 2016
Accepted: May 20, 2016

DOI: 10.2174/1567205013666160603010455

Abstract: The analysis of the facial expression of pain promises to be one of the most sensitive tools for the detection of pain in patients with moderate to severe forms of dementia, who can no longer self-report pain. Fine-grain analysis using the Facial Action Coding System (FACS) is possible in research but not feasible for clinical use at the moment because it is too time and effort consuming. Studies using the FACS showed either enhanced facial responses or no alterations of facial activity during pain in patients with cognitive impairment. Pain assessment in the clinical context relies strongly on the use of observational scales when self-report has become invalid. All of the established scales include items describing facial responses to pain. Despite this agreement, the content of these face items is very different, ranging from anatomically-based descriptions to inference of internal states. Recent studies let the anatomical orientation appear more promising. Automated video systems for the detection of pain in patients with dementia may lead to ground-breaking improvements of pain care in the future.

Keywords: Dementia, Alzheimer's disease, Facial Action Coding System, facial expression, observational scales, pain.

1. INTRODUCTION

Pain is recognized as a multidimensional response system, with subjective, physiological and behavioral components. Despite this consensus on the nature of pain, it is often seen mainly as a private and subjective experience, with pain report and rating as gold standard for pain assessment. This prejudice results in neglect of other forms of pain responses. However, a range of behavioral signs is associated with pain. Some behaviors, such as withdrawal or guarding, functionally aim at the reduction of physical threat, whereas other behaviors support communicative functions [1]. Changes in facial expressions of pain are examples of the latter [2]. There is wide agreement that facial expressions represent the most sensitive and specific non-verbal signals of pain [3]. This prominent role is also reason enough to suggest the assessment of facial expressions of pain in patients with dementia, when they are no longer able to provide valid and reliable self-report of pain [4-6].

Facial activity during pain has been intensely studied by use of the Facial Action Coding System (FACS [7]). The FACS is a fine-grained, objective, and anatomically-based coding system. It classifies facial movements using a comprehensive set of 44 operational definitions of such movements (Action Units), which allows for coding any facial expression. Investigators mainly code facial responses offline in slow motion after video segmentation. FACS has been successfully used in many fundamental and clinical pain studies; it has helped to unravel many puzzles with regard to the facial expression of pain. However, it is very time-consuming and requires much effort for relatively "little" data. Therefore, this way of scrutinizing facial expressions of pain is limited to applications in research and is not feasible for everyday clinical usage. As regards the pain assessment of patients in dementia, there have been a few informative studies, in which FACS was used and which are described in the next section (2).

However, most of the ideas about changes in facial expression during pain discernable in patients with Alzheimer's disease stem from behavioral observations guided more or less systemically by observational scales. These scales help the observer by describing in each item facial activities supposed to be indicative of pain to allow for objectively evaluating facial responses to pain. Such attempts will be reviewed in the next but one section (3.). The potential great advantage of automated video analysis for online pain detection has triggered world-wide activities trying to develop computer vision systems, which are briefly described in the last section (4.).

Before presenting the findings on facial expressions of pain in patients with dementia, a common misperception ought to be highlighted. Many believe that a perfect analysis of the facial expression of pain might serve as a 1:1 substi-

*Address correspondence to this author at Physiological Psychology, University of Bamberg, Markusplatz 3, 96047 Bamberg, Germany; Tel/Fax: +49-951-863-1851, +49-951-863-1976;
E-mail: Stefan.lautenbacher@uni-bamberg.de

1567-2050/16 $58.00+.00

tute for the compromised self-report of pain in patients with moderate to severe dementia. Theoretical and empirical reasons, however, speak against such a belief. The term facial expression of pain in itself is already misleading because it suggests a strict serial processing, with the subjective experience evolving first and the facial expression following after. However, the pain response system mostly runs parallel with mutual influences between the subjective and facial response levels at different points in time. This principal independency of the two response levels may explain why even under the best possible conditions, the relationship between subjective pain reports and parameters of FACS analyses are mostly only small [8]. Thus, the facial expression is an independent source of information, which helps to identify pain [9], and is often imperfect in exactly grading it. Disregarding the facial expression of pain as a valid pain indicator simply because of a weak correlation with pain ratings is therefore based on an erroneous conclusion.

The purpose of this paper is to review the available evidence about the facial expression of pain in dementia with the goal of demonstrating the still existing gap between experimental subtleties and clinical possibilities.

2. EVIDENCE FROM FACS ANALYSES

We aimed at a systematic review as regards FACS analyses of facial responses to pain in dementia and performed a corresponding search in February 2015, using the databases MEDLINE, Web of Science and PsychINFO. The search strategy consisted of text words and MESH terms covering: i) "dementia" or "Alzheimer" or "cognitive impairment" or “elderly” or “elders” or "cognitively impaired", and (ii) “pain” or “noxious”, and (iii) "facial" or “facial expression” or “FACS”. In addition, the reference lists in the publications included were examined to retrieve further relevant publications. This search resulted in 98 articles, which were examined in detail by the first and second author. Out of these 98 articles, 7 articles were included in this review (see Table **1**), using the following eligibility criteria:

(i) Original studies published in English peer-reviewed journals,

(ii) include individuals with dementia,

(iii) include data concerning pain,

(iv) include data concerning facial expressions being analyzed using the Facial Action Coding System.

The seven studies could be grouped into three categories, studies using experimental pain [10-12], a study investigating exacerbation of clinical pain during activity [13] , and studies using pain resulting from invasive clinical procedures [14-16]. In the two studies of Kunz *et al.* with experimental pain, the facial responses of patients (most patients were suffering from Alzheimer’s disease) were enhanced [10-11]. Interestingly, this increase in facial responses was not due to an overall unspecific increase in facial expressions, but only those facial movements that have been shown to be indicative of pain in former studies were displayed more frequently and with higher intensities in patients with dementia. These pain indicative facial responses are: tightening of the muscles surrounding the eyes, furrowed brows, raising the upper lip/nose wrinkling and eye closure [17]. Thus, the facial responses to experimental pain stimulation were increased in a pain specific manner in patients with dementia. In the third study by Lints-Martindale *et al.* [12] there was a trend towards more facial activity during pain in patients with Alzheimer´s disease.

In the one study, in which pain was produced by everyday stressors (sitting, walking, standing, transferring, reclining), only walking produced more facial activity in patients with dementia compared to controls.

In the three remaining studies, in which injections/venipucture were used as pain models, no differences between individuals with and without cognitive impairment were observed. Both groups showed equally enhanced facial activity during injection compared to baseline. Injections are known to be a poor model for experimental pain because the exact noxious impact is difficult to control and both health care professionals as experimenters and recipients have become over-trained over the years in their ability to distract the patient from focusing on the injection.

So, when combining the existing evidence patients with dementia appeared to be either more facially expressive than matched control subjects without cognitive impairment or at least equally expressive. The Action Units, which contribute most to this impression, are well-known as facial indicators of pain.

So far, one can only speculate why patients with dementia tend to show an increased facial expression of pain. One reason might be an intensified processing of noxious stimulation in patients with dementia. These intensified pain responses might in turn be due to the decline in capacity to anticipate pain and cope with pain. Alternatively, it may also be that facial responses to noxious stimulation are increased simply because the ability in patients with dementia to control the impulse to facially display their inner state is impaired. We learn mainly in the course of childhood to inhibit the facial display of negative affective states, such as pain, to comply with certain display rules. This ability to adjust the facial responses to pain to the social context might be impaired in patients with dementia.

With the exception of the study by Kunz *et al.* [11] all other studies mainly used a composite FACS score, which summarizes/averages facial activity over various Action Units. According to these analyses, it is only roughly possible to determine whether the usual pain-specific facial pattern is preserved. Qualitative analyses focusing on distinct patterns of Action Units that also take into account serial information might reveal whether pain in dementia shows a “different face”, but such analyses are still missing.

There are a few reasons suggesting these qualitative analyses might be worthwhile. It is possible that dementia might affect the lower and upper part of the facial expression of pain differently. Whereas the upper part of the face is mostly controlled by the subcortical extrapyramidal tract that drives spontaneous or reflexive expressions of emotions, the lower part is additionally also controlled by the cortical pyramidal motor tract that drives voluntary facial expressions [18]. Of course, there is some overlap because reflexive sys-

Table 1. Studies on facial responses to pain in dementia, in which FACS-analyses were used.

Authors	Participants	Pain Induction	Results
Hadjistavropoulos *et al.* [14]	26 frail elderly (all with cognitive impairment); mean age: 78 years	immunization injection	Facial responses significantly increased during injection compared to baseline. No difference in facial responses between participants still able to self-report pain and those who were not
Hadjistavropoulos *et al.* [15]	59 frail elderly (24 with cognitive impairment); mean age: 73 years	blood sampling (venipuncture)	Facial responses significantly increased during venipuncture compared to baseline. No difference in facial responses between cognitively impaired and unimpaired patients
Hadjistavropoulos *et al.* [13]	58 frail elderly undergoing psychotherapy for a variety of conditions (29 with cognitive impairment); mean age: 77 years	due to everyday activities (sitting, walking, standing, transferring, reclining)	Walking elicited more facial responses in cognitively impaired patients compared to non-impaired patients
Hsu *et al.* [16]	22 frail elderly (10 with cognitive impairment); mean age: 88 years	local anesthetic injection for dental procedures	Facial responses significantly increased during injection compared to baseline. No difference in facial responses between cognitively impaired and unimpaired patients
Kunz *et al.* [11]	87 elderly (42 with cognitive impairment (mostly Alzheimer's disease)); mean age: 75 years	pressure on the volar forearm	Patients with dementia showed increased pain-specific facial responses compared to control subjects
Kunz *et al.* [10]	81 elderly (35 with cognitive impairment (mostly Alzheimer's disease)); mean age: 75 years	electrical stimulation of the n. suralis	Patients with dementia showed increased pain-specific facial responses compared to control subjects
Lints-Martindale *et al.* [12]	63 elderly (27 with Alzheimer's disease); mean age: 88 years	electrical stimulation of the n. suralis; pressure on the thumb	No difference between Alzheimer and control subjects (not-significant trend towards stronger responses in patients)

tems are also subject to voluntary control. Nevertheless, it might worth considering whether in dementia there are – besides quantitative alterations - also qualitative changes in facial activity, changing the balance between upper and lower face expression. Interestingly, Kunz *et al.* [19] found that facial movements around the eyes mostly encode sensory pain aspects, whereas movements of the eyebrows and of the upper lip were closely associated with the affective pain dimension. Thus, such qualitative changes in facial activity might also change the content of the facial pain message. There is already some evidence for – at least – some qualitative changes in facial activity in patients with dementia. Kunz *et al.* [11] found that patients with dementia (mostly Alzheimer's disease) respond to pain by opening the mouth more frequently. Although opening of the mouth is not listed amongst the prototypical pain indicative facial responses occurring during pain, this facial movement has nevertheless been frequently reported in the context of pain, even in cognitively unimpaired individuals [9]. Thus, opening of the mouth is not an atypical facial response to pain, but may become especially pain-indicative in patients with dementia.

3. EVIDENCE FROM OBSERVATIONAL SCALES

Meanwhile many observational scales for pain in dementia exist. However, most of them have poor psychometric quality. Firm evidence about the best possible choice of a tool is still missing [20]. Despite this unclear situation, there is general agreement that facial items have to be included in any observational pain scale. An expert group funded by COST (European Cooperation in Science and Technology) conducted a search for the best established observational scales for pain assessment in dementia and extracted the most frequently used and clinically meaningful items. They found a large variety of operationalizations of facial items [20]. The set of facial descriptors most commonly used is given in Table **2**.

Most of the facial items included in the established observational scales are strictly descriptive and do not infer inner states from facial expressions (sub-categories: "anatomically-based descriptions" and "autonomic reactions"). The anatomically-based items show a good overlap with those Action Units revealed by FACS analyses as pain relevant, which are mainly "lowering and drawing brows together" (frowning), "narrowing eyes" and "raising upper lip." However, there are several facial items included in the established observational scales, which rely strongly on the interpretation of observations (sub-categories: "cognition" and "emotional state"). The remaining item "pained expression" does not really call for detailing visible facial activity but attempts to bridge a general observation of facial activity and the inference of pain in one step. If it would be that easy,

Table 2. Facial items most commonly used in observational scales for pain assessment in dementia [20].

Item	Description	Sub-category
Frowning	Lowering and drawing brows together	Anatomically-based descriptions
Narrowing eyes	Grimacing, narrowed eyes with tension around the eyes	Anatomically-based descriptions
Closing eyes	Not just blinking	Anatomically-based descriptions
Raising upper lip	Grimacing, upper lip raised, nose may be wrinkled	Anatomically-based descriptions
Opened mouth	The lips are parted, jaw is dropped	Anatomically-based descriptions
Tightened lips	Lips are pressed together and appear more narrow	Anatomically-based descriptions
Clenched teeth	Teeth are pressed together with tension	Anatomically-based descriptions
Empty gaze	Eyes do not reflect any emotion or thinking activity("blank expression")	Cognition
Seeming disinterested	Face does not reflect any interest in the environment	Cognition
Pale face	Pale skin colour	Autonomic reactions
Teary eyed	Watery eyes	Autonomic reactions
Looking tense	Facial display of strain or worry	Emotional state
Looking sad	Facial display of unhappiness, sorrow or low mood	Emotional state
Looking frightened	Facial display of fear, alarm or heightened anxiety	Emotional state
Pained expression	Facial display of pain	Qualitative judgment of expression

the times of more detailed analyses would have already been over.

In a metaphoric sense, the developers of observational scales for pain assessment in dementia unanimously agree to believe that the face is telling an important story about the pain in patients with dementia; however, they cannot agree on which are the "critical phrases" in that story. The COST experts mentioned earlier try to find out which of the facial items are especially helpful for the detection of pain.

Not on the item level, but on the scale level, Sheu *et al.* [21] compared six well-established scales as regards the usefulness of the facial items in the prediction of pain and concluded that scales that provided specific descriptions using the empirically displayed facial actions associated with pain yielded greater sensitivity, interjudge reliability, and validity as indices of pain. This finding and the suggestion of using anatomically-based descriptors by most of the scale developers favor such largely descriptive face items for observations during everyday pain care.

4. AUTOMATED VIDEO DETECTION OF PAIN

The usefulness of the anatomical fine-grained analyses of the face in the search for pain provided by FACS, in combination with its extreme time- and effort-consuming properties, has for some time elicited the wish of developing automated computer vision systems for the detection of pain. Despite repeated claims of a breakthrough in mass media, the suitability of these automated computer vision systems for clinical use is still not given. Some of the available systems have developed impressive solutions for mapping the face [22-23]. However, strong movements of the head still lead to erroneous tracking of the face. Another development worth mentioning is the identification of single pain-relevant Action Units; this may also be possible for some simple combinations of pain-relevant Action Units. However, the reliable identification of the whole inter-individual variety of typical and atypical pain faces is still not possible. Since the facial activity patterns associated with pain are individually very different, machine-learning might help to extract the valid activity pattern for each single patient [24-25]. However, it is difficult in the clinical context to feed such systems with sufficient suitable video material for machine learning. Critical information to be used by computer vision systems is the types of the Action Units and their sequence.

Although we are at the moment still a little skeptical, the authors of this article see in the automated detection of pain by computer vision systems one of the ground-breaking developments in pain care of patients with dementia in the future. Such systems may prevent unnecessary suffering of the frail elderly, when they finally become feasible in nursing homes and similar institutions [5].

CONCLUSION

The analysis of facial expression promises to be an alternative and independent source of information for the detection of pain in the elderly with cognitive impairments. Especially patients with dementia appeared to communicate pain specifically via facial expressions and often showed enhanced facial activity during pain compared to cognitively healthy individuals. The most useful application may be the detection of pain, not its fine grading. At the moment FACS coding as a tool is too time- and effort-consuming and the

available observational scales for assessing the facial activity patterns associated with pain are not yet sufficiently developed and validated. Therefore, more research is still required in these two domains because the promise of the future, namely automated computer vison systems for the detection of pain will not be available tomorrow for the use in nursing home and similar institutions.

LIST OF ABBREVIATIONS

COST = European Cooperation in Science and Technology

FACS = Facial Action Coding System.

CONFLICT OF INTEREST

There are no conflicts of interest.

ACKNOWLEDGEMENTS

We acknowledge the support from the COST program (European Cooperation in the field of Scientific and Technical Research) for COST Action TD 1005, "Pain Assessment in Patients with Impaired Cognition, especially Dementia"

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