Practice points

- Facial expressions can reliably be used for pain assessment purposes in dementia
- All pain behavioral observation tools contain facial expression descriptors; however, the exact definition of what pain-indicative facial expressions are varies widely between scales
- Evidence is needed on the precise critical facial movements or the critical facial descriptors that validly indicate pain being present in the patient, to increase the clinical utility of facial expressions in daily practice
- When using facial expressions for pain assessment in dementia, potential confounding roles of behavioral changes need to be considered, including disinhibition, apathy and emotional disorders
- Some behavioral and emotional changes in dementia appear to be pain-indicative, as pain treatment successfully reduces these changes. These may include agitation, apathy, and depression
- When using facial expressions as pain indicators, it is advisable to use multiple moments of observation and to be aware of possible observer bias. Taking into account a baseline moment (e.g., observation during rest) could offer valuable insight in possible expressions of pain
- Health care professionals familiar with patients suffering from pain are not better in recognizing or evaluating pain, and may even undervalue expressions of pain in others. Specific training on which facial expressions indicate pain, or how to use observational scales for pain assessment purposes, is recommended

Abstract

Facial expressions convey reliable non-verbal signals about pain and thus are very useful for assessing pain in patients with limited communicative ability, such as patients with dementia. In this review, we present an overview of the available pain observation tools and how they make use of facial expressions. Utility and reliability of facial expressions to measure pain in dementia will be discussed, together with the effect of dementia severity. Next, we present how behavioral alterations may overlap with facial expressions of pain, and may even influence the extent to which pain is facially expressed. The main focus is on disinhibition, apathy and emotional changes. Finally, an overview of theoretical considerations and practical implications is presented for assessing pain using facial expressions in clinical settings.

Keywords: Dementia; Cognitive Impairment; Pain Assessment; Facial Expression; Subjective Pain Report; Expertise; Neuropsychological Functioning; Disinhibition; Apathy; Emotional Changes.

Introduction

Dementia, or major neurocognitive disorder, is diagnosed when there is evidence of cognitive decline from a previous level of performance in one or more of the following cognitive domains: complex attention, executive function, learning and memory, language, perceptual motor and social cognition. The cognitive decline moreover interferes with independence in everyday activities, and cannot be attributed exclusively to a delirium or to another mental disorder [1]. It is not unexpected that this cognitive decline significantly limits pain assessment, as it reduces patients' ability to communicate about their pain. Moreover, these patients lose the ability to comprehend and use commonly applied pain scales; according to a previous study, only 40% of patients suffering from severe dementia were still able to use one out of four pain scales [2]. The substantial prevalence of pain in dementia, which has been estimated to be as high as 70–80% in adults residing in care facilities [3–5], highlights the importance of valid pain assessment tools in this frail population, in order to optimize pain treatment and prevent suffering. For this reason, there has been a recent upsurge in the development and validation of pain observation scales. The American Geriatric Society (AGS) Panel on Persistent Pain in Older Persons advises the use of six main categories that are indicative for pain in cognitively impaired older adults [6]. These six categories are: facial expressions, verbalizations and vocalizations, body movements, changes in interpersonal interactions, changes in activity patterns or routines, and mental status changes.

Within the domain of behavioral pain indicators, facial expressions of pain may be particularly useful, as they are currently regarded to be very reliable indicators of pain experience [7–9]. Studies have for example demonstrated that, amongst different behavioral observation domains (e.g., bodily posture, vocalizations), facial expression is the most reliable and most discriminate pain indicator in the first few months of life [10,11]. However, there are several aspects that need to be considered when using these scales and interpreting facial expressions as

indicative of pain. The goal of this review paper is to provide a critical evaluation of the use of facial expressions for pain assessment in people with dementia. For this, we first provide an overview of different facial pain expression items incorporated in observation scales, together with evidence in support of the reliability and validity of facial expressions for use in older populations. Here, we also review the effect of dementia severity on facial expressions of pain. This is followed by a discussion regarding the interrelatedness between pain-specific and more general behavioral changes in dementia, including an evaluation of the role of behavioral disinhibition, apathy, and emotional changes. We end with practical issues and clinical implications, providing practical guidelines for the use of facial expressions of pain in the geriatric setting.

Observation scales, validity in dementia, and the effects of dementia severity

In the next section, a brief summary is provided of facial expressions that are incorporated in commonly-used pain observation instruments. This is followed by a discussion of studies that support the assumption that facial expressions can successfully be used in order to detect pain in patients with dementia. Finally, the effect of dementia severity on the degree of facial expressiveness to pain, and how it affects utility of observational scales that assess facial indicators of pain, will be discussed.

Available observation scales

During the last two decades, the interest in pain assessment in dementia has resulted in numerous systematic reviews addressing the availability and psychometric quality of observational pain assessment tools [12–19]. Although available tools vary considerably in terms of, for example, scoring format and comprehensiveness of items used, they all included items relating to facial

expressions. However, the operationalization of what is a pain-indicative facial expression differs immensely between scales. In Table 1, a summary is presented of the facial items used in observational tools to assess pain in dementia [20–32]. A detailed overview of the most common pain observation tools mentioned in previous reviews, together with a detailed description of the included facial pain expression items, can be found in the online supplementary Table. Most pain tools use one categorical item that is usually referred to as 'Facial expression(s)'. Most often the categorical item 'Facial expression(s)' is specified in the scoring instruction as changes relating to the area of the mouth (clenching or grinding teeth) and the eyes (frowning, tightening the eyes). Some scales use items that are less pain-specific and could also refer to emotional states (such as 'widening eyes', which could also reflect increased levels of anxiety). The minority of pain tools includes more detailed indicators of facial responses to pain. For example, the authors of the PACSLAC, a tool used to screen for pain in older adults who have dementia or other cognitive impairment with a limited ability to communicate, have chosen to include more detailed changes (13 facial items).

- Insert Table 1 about here -

Besides these behavioral pain assessment tools, facial responses to pain have been assessed using the Facial Action Coding System (FACS). FACS is a method designed to objectively describe detailed facial expressions of pain. FACS can reliably be used to code pain-related expressions in non-communicative individuals, such as dementia patients [33]. The method classifies the intensity and frequency of facial responses based on the anatomy of the face. For this, the facial responses are analyzed using so-called Action Units to classify the facial responses. It should be acknowledged that the FACS is often used in experimental pain research

but cannot be used in daily clinical practice, because it requires extensive training and because real-time scoring using the FACS is not possible.

Most of the facial items included in established observation scales are strictly descriptive and do not infer inner states from facial expressions (e.g., blinking, furrowed brow, see Table 1). Some of these more anatomically-based items show a good overlap with findings on facial expressions of pain based on fine-grained FACS analyses [7,34]. For example "frowning", "narrowing eyes" and "raising upper lip" are all facial movements that have been shown to occur during pain. However, there are several facial items included in established observational scales, which rely strongly on the interpretation of observations (e.g., looking sad, looking frightened, see Table 1). Some scales include an item labeled vaguely as "pain expression". Such an item does not call for detailing visible facial activity but attempts to bridge a general observation of facial activity and the inference of pain in one step. However, if it were so easy to detect pain, the further detailed analyses would not be necessary.

At a scale level, Sheu et al. [9] compared six well-established scales as regards the usefulness of the facial items in the prediction of pain. They concluded that scales that provided specific descriptions using the empirically displayed facial actions associated with pain yielded greater sensitivity, inter-rater reliability, and validity as indices of pain. This finding, combined with 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.

To summarize, one could say that the developers of observational scales for pain assessment in dementia unanimously agree that the face is an important channel for pain communication. Unfortunately, developers of these scales do not agree on the precise critical facial movements or the critical facial descriptors that validly indicate pain being present in the patient. We have marked those items that are used most often in observational scales for pain

assessment in dementia in Table 1. However, the frequency of use does not automatically mean that these are indeed the best items. An expert group funded by COST (European Cooperation in Science and Technology) (TD1005) has started to systematically investigate which of the facial items are especially helpful for the detection of pain using experimental as well as clinical protocols. Results of the European approach can be expected to be published later this year.

Validity in dementia

Previous studies examining the extent to which facial expressions can reliably be used as indicators of pain have shown promising results. Lints-Martindale et al. [33] showed that facial expressions, as measured with the FACS, could differentiate between different levels of painful and non-painful stimulation, and that this was possible in healthy older people and in people with Alzheimer's disease (AD). Kunz and co-workers [7] demonstrated that patients with dementia display a specific increase in pain-related, but not in pain-unrelated, facial expressions, suggesting that facial expressions can be used as a sensitive and specific method to detect the experience of (experimental) pain. This was recently supported by Beach et al. [35]. They showed that patients with AD display an increase in pain-related, but not pain-unrelated, facial expressions in response to noxious stimulation. Moreover, they demonstrated that AD severity was unrelated to the amount of facial expressions displayed, suggesting that these expressions are useful as pain indicators regardless of dementia severity (see however the next section for a discussion on the effect of dementia severity of facial expressions). Also in these latter two studies, the FACS was used to measure facial expressions in response to pain.

To what extent these facial expressions can successfully replace subjective pain reports remains, however, an issue of debate. Naturally, once patients lose the ability to communicate about their pain, observational tools provide the best possible alternative for pain assessment

purposes. Nonetheless, it is widely agreed that one should always try to obtain a subjective pain indication from the patient. A striking observation is that these self-reports actually do not strongly correspond to the level of facial expressions displayed. For example, Lints-Martindale et al. [33] found no significant correlation between the subjective report of pain and the level of facial reactivity following painful stimulations in AD. Similar findings have been reported in older adults [33,36]. What does this lack of strong association between self-report and facial expression mean? Is facial expression not a valid indicator of pain? Many believe that a perfect analysis of the facial expression of pain might serve as a 1:1 substitute for the impaired self-report of pain in patients with moderate to severe dementia. Theoretical and empirical reasons, however, contradict this 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 [37]. 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 [38]. Thus, facial expression is an independent source of information, which helps to identify pain [39], with facial and subjective responses capturing different aspects of the multidimensional pain experience [40] and both response systems being affected by different influences (see Figure 1). 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. Nonetheless, this suggests that these pain assessment methods should not be used interchangeably. When a patient is still able to provide a subjective pain report, this should always be obtained as it encompasses important information about pain experience, in addition to facial expressions.

- Insert Figure 1 about here -

Dementia severity

There has been little empirical research on how facial expression of pain changes as dementia progresses. Conducting experimental pain research in this population is difficult, and indeed many pain studies have selectively excluded participants who are "non-communicative" [41]. In people with mild cognitive impairment (MCI), sometimes described as very early or "preclinical" dementia, facial responses to electrical pain stimuli were not altered compared with healthy controls of the same age [42]. As dementia advances, people experience an increasing impairment in recognizing the facial expressions and emotional states of others [43], and in addition apathy, a common symptom which becomes more common as dementia advances, may cause emotional blunting (a lack or reduction in the range of emotional responses displayed in the person with dementia [44]). In the advanced stages of dementia a person may be bedbound, unable to speak, smile or lift their own head up and clinical assessment of facial signs of pain becomes more challenging. A study of Kaasalainen and colleagues [45] indicated that pain behaviors varied as a function of residents' ability to verbally report pain, and this could reflect the dementia severity. Residents able to self-report pain displayed, for example, less frequent facial expressions like opening mouth and grimacing. In line, there is some evidence that in advanced dementia facial expression is an indicator of the presence of pain, but not necessarily its intensity [46]. We also do not know how other sources of physical discomfort (for example, poor positioning, feeling cold) or emotional distress (for example fear or boredom) impact on facial expression as dementia moves into the advanced stages; it is therefore crucial to realize that changes in facial expression may be due to wider physical or emotional distress, rather than purely nociceptive stimuli [47].

Behavioral changes in dementia may affect facial expression: disinhibition, apathy and emotional changes

One crucial issue that needs consideration when assessing behavioral indicators of pain in dementia is that dementia is characterized by behavioral changes in general. For example, agitation, aggression, apathy, depression, hallucinations and delusions are common in dementia, particularly when the disease progresses. However, several studies have demonstrated that behavioral changes may already be present early in the disease process. This holds true not only for diseases characterized by early behavioral alterations such as frontotemporal dementia (FTD) [48], but also in diseases such as Alzheimer's dementia [49,50], which are traditionally associated with early cognitive decline as one of the prominent features [51].

In the next sections, we will highlight behavioral changes that potentially influence or might even bias scoring of facial expressions as indicative of pain. First, we discuss the potential confounding effects of behavioral disinhibition, as behavioral disinhibition is very common in dementia and results in uncontrolled (inappropriate) behaviors, including impaired control of emotional and social reactions. It is likely that such impairments in behavioral control are also evident in increased facial reactivity following noxious stimulation. In addition, as Sheu and colleagues [9] pointed out, some specific behavioral changes, that are in itself unrelated to pain, are nevertheless listed in some pain observation tools. Examples here include items that refer to the absence of an affective or emotional state (e.g., 'a staring face'), or items that refer to emotional states that may be independent of the presence of pain (e.g., 'a frightened face') [9]. Based on these findings, we will additionally discuss apathy and emotional changes.

Disinhibition

Behavioral disinhibition is an important characteristics of diverse dementia subtypes [52,53]. A

previous study in a large sample of dementia patients demonstrated that primarily (pre)frontal structures are associated with behavioral alterations, with disinhibition relating to the lateral orbitofrontal cortex and the subgenual cingulate gyrus [52]. Other studies support these findings, showing common associations between frontal brain structures and behavioral disinhibition, together with a high prevalence in different dementia subtypes. Less is known with regard to the specific inhibition of facial expressions in dementia, although some studies have been conducted on this topic. Goodkind et al. [54], for example, examined the down-regulation (i.e., the intentional hiding) of emotional facial expressions in controls, patients with AD and patients with FTD. Participants were presented with an acoustic stimulus that was either preceded by a warning (warned condition) or not (unwarned condition). This acoustic stimulus was used to induce a startle response, which was operationalized by emotional facial reactivity (measured using the Expressive Emotional Behavior Coding System, which is based on the FACS) and overall body movement. In addition, participants did not receive any instructions of how to react to this acoustic stimulus, or there were specifically instructed to hide their facial emotional reaction to this stimulus. This resulted in three conditions: 1. An unwarned condition where no instructions were given to down-regulate (i.e., hide) facial reactivity; 2. A warned condition without instructions to down-regulate, and; 3. A warned condition combined with instructions to down-regulate. They found that all patients displayed normal startle responses following the unwarned condition (Condition 1). However, when they were instructed to down-regulate their facial expressions (Condition 3), it turned out that the AD and FTD patients were less able to successfully do this. When they only received a warning, but no instructions to down-regulate (Condition 2), it appeared that only AD patients and healthy controls were successful in inhibiting their facial responses. This finding of deficient inhibition of facial expressions in dementia is supported by some [55], but not all [56,57], studies.

A crucial question is whether inhibition is also related to the intensity of facial expressions following painful stimulation [58]. Two very recent studies addressed this question in healthy younger [59] and older [60] participants. Karmann and colleagues [59] examined both cognitive inhibition, corresponding to inhibitory control over mental processes, and motor inhibition, referring to the inhibition of motor/behavioral processes, in relation to facial expressions following experimental pain. Motor inhibition was measured using the antisaccade task, in which participants have to inhibit making a saccade towards a previously cued location. Cognitive inhibition was measured using the Stroop Color and Word Test; here, participants are presented with color names printed in an incongruent color (e.g., the word 'red' printed in green ink) and have to name the ink color whilst inhibiting reading the word. They found that an increase in motor inhibition ability (i.e., better motor inhibition functioning) was associated with a reduction in the intensity of facial expressions displayed in response to noxious stimulation, whereas no such result was found for cognitive inhibition. Such a unique association with motor inhibition seems likely, as facial expressions concern automatic reflexive muscle movements. In older adults, it was furthermore found that cognitive inhibition (also measured with the Stroop Color and Word Test) moderates the extent to which an increase in applied painful stimulation induced an increase in facial expressions [60]. Here, older adults with reduced cognitive inhibitory abilities (i.e., those who were worse in inhibiting their responses) showed a stronger increase in facial expressions as the level of pain (induced by mechanical pressure) increased compared to older adults with good cognitive inhibitory abilities. A similar effect was observed for the subjective pain report, suggesting that with increasing painful stimulation, reduced cognitive inhibition was not only associated with increased facial expressiveness, but also with an increase in the self-reported level of pain. As such, in these older adults with reduced cognitive inhibitory control, there is a higher chance of observing facial expressions in response to painful

stimulation. This suggests that facial expressions may be more informative regarding the presence (or even severity) of pain in this selected group of older adults.

Apathy and emotional changes

Another behavioral change that should be addressed here is apathy, as it is one of the commonest behavioral changes reported in dementia, including AD and FTD [52,53,61]. Bruen and co-workers [62] found that some level of apathy was present in 74% of patients with early Alzheimer's disease. Rosenberg and co-workers [53] demonstrated that a wide network of brain regions, typically affected in AD, underlies apathy, including the frontal cortex, orbitofrontal cortex, anterior and posterior cingulate cortex, and the inferior temporal cortex. A recent review underlines the importance of prefrontal and anterior cingulate cortex regions in apathy [63]. This expression of apathy in dementia patients poses some difficulties for items of available pain observation tools that encompass observations such as 'a blank expression' [9]. As these items may indicate either the absence or the presence of pain, apathy as a neuropsychiatric feature of dementia may mistakenly be interpreted as an indicator of (the presence or absence of) pain. Also, as Sheu et al. [9] pointed out, several pain items of observation scales are not specific for pain, as they reflect more general emotional states. As emotional disorders such as depression and anxiety (or emotion-related behavioral changes such as aggression) are also more common in dementia, there is an increased risk that these symptoms are interpreted as indicating the presence of pain. However, a previous study demonstrated that both apathy and depression, but not anxiety or irritability (among others), improved following pain treatment [64], indicating that some behavioral and/or emotional changes might be more closely related to pain than others. Currently very little is known about this; a recent review nonetheless showed that particularly depression, agitation, and other behavioral disturbances such as wandering and physical and verbal abuse,

may be associated with pain [65]. Furthermore, Husebo and colleagues demonstrated that pain treatment reduces behavioral disturbances, primarily agitation, in elderly people suffering from dementia [66,67]. Taken together, these findings do suggest that factors such as depression, apathy and agitation may be linked to pain.

Practical and clinical implications

Several issues need consideration when using facial expressions as pain indicators in clinical practice. All effort should be made to obtain the most reliable pain indication possible, not only by ensuring that the expressions a patient displays are truly indicative of pain, but also by ascertaining that these expressions are properly recorded. In the next sections, the role of context will be discussed, followed by a brief section on the effect of dementia subtype on pain assessment and outcome. We end with a discussion about the potential influence of observer's experience and clinical considerations.

Context of the pain assessment

Context refers to both the surroundings in which the patient is observed (external context) and the knowledge of the patient regarding the current situation (internal context). We start first with a discussion of how the internal context may be altered in dementia, followed by suggestions for how the external context may be managed in order to obtain reliable pain assessments.

Dementia in general is characterized by a loss of semantic and episodic memory. This means that patients forget their personal experiences with, for example, painful situations they encountered (episodic memory) and also lose their general knowledge regarding situations (semantic memories). Hence, patients with dementia lose their earlier acquired internal context of pain experience, which may have profound consequences for how patients respond to pain. In

general, our knowledge (both episodic and semantic) allows us to prepare for upcoming adverse situations. Seeing an injection needle, we know that we are about to experience a brief period of mild pain, but that it will pass soon. This is based on both our previous experiences (e.g., last time we received an injection the pain was only mild) and our general knowledge regarding injections (e.g., injections are in general not very painful and won't last long). It was recently demonstrated that semantic dementia patients, who have a severe decline in semantic memory, show increased responses to sensory input [68]. Presumably, a loss of context increases fear responses in these patients as situations cannot be anticipated, resulting in stronger reactions to sensory input [69]. From this perspective, it is possible to assume that in dementia responses to pain (e.g., facial and verbal reactivity) will increase as the situational knowledge and memories are lost.

Although this remains highly speculative, a previous study did demonstrate that dementia patients indeed show a decline in their semantic knowledge of pain, and that this loss was inversely related to pain estimates [70]. That is, a decline in semantic knowledge of pain was associated with an increase in pain the patients estimated a certain situations would cause (e.g., the pain caused by sustaining a burn injury). Hence, it is likely that the loss of contextual knowledge will make people respond more strongly to pain, which includes an increased facial expression following painful stimulation; whether such increases reflect a genuine increase in pain experience, or whether they reflect mere indications of surprise (as the knowledge loss reduces anticipatory capabilities) is currently unclear. Nonetheless, it is crucial to bear in mind that studies have demonstrated enhanced somatosensory experience in patients with conditions such as semantic dementia [68,71] and progressive non-fluent aphasia [71], suggesting that enhanced pain responses could very well reflect true increases in pain experience.

These findings have important implications for clinical practice and the external context. Observations of possible pain behavior should be preferably performed in a natural environment after allowing the resident some time to become adjusted to the context of observations. To reduce possible bias in cues displayed it is advisable to use multiple moments of observation [31]. Taking into account a baseline moment (e.g., observation during rest) could offer valuable insight in possible expressions of pain that are related to the person observed also in non-painful situations or conditions.

The impact of dementia subtype

An important issue that has barely been examined to date concerns the effect of dementia pathology on patients' responses to pain. For example, whereas patients with vascular dementia have been shown to report more pain compared to cognitively intact elderly controls [72,73], those two studies on patients with (frontal variant of) FTD suggest a decrease in pain in these patients, as was demonstrated by proxies' evaluations of patients' pain experience [74] as well as by a study showing increased pain threshold and tolerance levels in these patients [75]. Results in AD are more mixed, however, with some studies pointing to an increased pain reactivity [76] in these patients. Little is known regarding pain in other dementia subtypes, such as Lewy Body dementia [77].

With regard to the facial expression of pain, most studies have been conducted in AD patients. Again, findings are mixed; however, most findings point to an increase in facial responses to experimentally induced pain [76]. With the exception of Kunz et al. [7], who found no differences in facial expressions between patients with AD, vascular dementia and mixed forms of dementia (however, the sample size was very small), no studies have focused on facial expressions of pain in other dementia subtypes. As a consequence, determining the clinical utility

of facial expressions for use in different dementia subtypes remains difficult. We can only speculate about potential issues that limit use of these expressions. For example, whereas facial expressions of pain might be increased in FTD (potentially due to a diminished inhibitory control), clinical and experimental pain experience might actually be reduced in these patients [74,75]. It is currently unclear how these divergent findings interrelate, or which pain assessment scale should be used as the gold standard in this and other dementia populations.

Expertise in pain assessment

It has been repeatedly shown that health care professionals with long-standing experience of patients in pain do not show a better ability to recognize or evaluate the pain of others based on their facial expressions [78], but sometimes even tend to underestimate pain in others more than non-professionals do [79,80]. Therefore, long term experience with patients suffering from pain does not by itself improve the ability to utilize facial expression to detect and judge pain and thus, specific training on facial expressions of pain or how to score facial expressions using observational pain scales might improve the decoding ability in health care professionals.

Clinical considerations

An important question is when, and how, facial expressions can be used in clinical practice. Apart from the obvious use in the case of non-communicative patients, it is advisable to use facial expressions in geriatric settings as an addition to subjective reports whenever possible. This is particularly the case if an older person reports no pain (in the presence of a disabling and/or painful conditions), or has a reduced ability to report pain; in such instances, assessing pain through facial expressions is highly recommended. Our advice is to respond to either verbal or facial indicator of pain and investigate the patient further. If the patient reliably shows pain

behavior, regardless of whether it is solely via self-report, via the facial expression, or both, treatment seems advisable. For example, when people report pain is present, facial expressions can be used for confirmatory purposes or to monitor the response to treatment, but pain report should be sufficient as it is viewed as the golden standard to initiate treatment. Some people are "facially stoic" and might not display pain via the face. In case of non-communicative, severely demented patients, additional information can be obtained by for example considering potential conditions that can cause pain or discomfort and reports from family members or caregivers (see [81] for a detailed account on pain assessment in persons with advanced dementia).

Finally, it is should be noted that neurological comorbidities may be present that potentially influence emotional expressions, thereby limiting the reliability of facial expressions of pain. One such example is pseudobulbar affect (or involuntary emotional expression disorder), a neurological disorder that impairs the inhibition of emotional affect, which may result in uncontrolled, exaggerated emotional responses (e.g., uncontrollable crying). This disorder is present in approximately 10-38.5% of all patients diagnosed with Alzheimer's disease and other dementias [82,83], and may thus interfere with facial expressions of pain in a substantial proportion of patients diagnosed with dementia. For example, the disinhibited reactions caused by this neurological disorder likely result in exaggerated facial displays following daily care situations such dressing or bathing. As a result, for these patients an increased risk exists that this disinhibition is mistakenly interpreted as pain, or that these uncontrolled expressions make one believe that severe pain is present, whereas the pain may be only mild. In contrasts, extrapyramidal symptoms also might affect facial expressions displayed, for example in patients with Parkinson's disease (PD) or Lewy body dementia [84]. Extrapyramidal signs are reported in up to 50% of Lewy Body dementia patients and may directly affect the pain expressions. Due to a

lack of facial expressions in Lewy Body dementia, signs may be absent or difficult to observe [85]. In Parkinson's disease hypomimia, a reduced degree of facial expressivity, is a key clinical symptom. Investigators have found reduced overall facial activity in response to pain in PD, and also a qualitative difference in the facial expression of pain with increased mouth opening and less narrowing of the eyes [86]. As such, facial expressions may be less reliable indicators of pain once (concomitant) PD or Lewy Body disease is present.

Conclusions and further perspectives

The analysis of facial expression promises to be a specific, alternative and independent source of information for the detection of pain in older people with dementia. The current review does, however, show that observation scales differ significantly in the definition of what precisely pain-indicative facial expressions are and how they are defined. The decision to use a specific observation tool furthermore depends on the precise setting in which the assessment is conducted and the population at interest [87]. In addition, in measuring facial expressions with observation scales, it is crucial to realize that behavioral alterations such as disinhibition, apathy and emotional changes may influence, and thereby reduce the reliability of, facial expressions of pain, although several behavioral alterations (e.g., depression, apathy and agitation) may truly be linked to pain. Finally, when measuring facial expressions for pain assessment purposes in dementia, several factors need to be considered in order to increase reliability of these assessments. These include the external surroundings and momentary circumstances in which the pain assessment is performed, the fact that expert-raters may underestimate pain, and the potential confounding effects of neurological disorders and dementia subtype on the facial expressions displayed.

Interestingly, patients with dementia often show enhanced facial activity during pain

compared to cognitively healthy individuals. The increase in facial activity might be due to loss of inhibitory functioning that controls the outward expression of pain. Whereas we learn to inhibit the facial expression of negative affect in our childhood, this learned inhibition may be lost in the course of dementia. This means that patients with dementia might facially express their pain in a more unfiltered manner. In addition, the loss of contextual knowledge may lead to an increase in responses to pain, which may be due to increased pain experience and/or an increase in surprise as anticipatory capabilities are diminished. However, the extent to which these inhibitory and contextual factors truly affect pain experience, and not only e.g. the motor response as evident in increased facial expressions, needs further examination. It is important to note here that the assessment of these inhibitory and contextual factors may not be extremely time-consuming. Inhibitory functions can, for example, be assessed using questionnaires (e.g., the Neuropsychiatric Inventory for Nursing Homes [88] to assess behavioral disinhibition) completed by a caregiver acquainted with the behavior of the patient, or through (neuro)psychological testing, using validated tests for which norm scores are available (such as the Stroop Color and Word Test [89] for cognitive inhibition), administered by a trained (neuro)psychologist.

Future research must also clarify which facial descriptors are truly indicative for pain in which type and which stage of dementia. This is a challenging task for several reasons. For example, dementia-related behavioral alterations (such as depression and apathy) might not only affect the facial expression of pain but might also be directly linked to pain (e.g., pain leading to apathy) [65], thus making it difficult to disentangle them. Whereas apathy, disinhibition and emotional changes may directly overlap with these facial expressions, little is known regarding how other behavioral changes such as delusions, hallucinations or euphoria may overlap with facial pain items or even confound the scoring of facial expressions. Moreover, scales differ immensely with regard to which facial descriptor is truly indicative for pain. This significantly

reduces the clinical utility of facial expressions in order to detect pain. Recently, some efforts have been made to identify facial items that help observers to correctly infer the presence or absence of pain. For example, a recent study in healthy participants demonstrated that particularly 'frown lines' (e.g., contraction of the eyebrows) and 'mouth' changes (e.g., lifting the upper lip and opening the mouth) might help to correctly identify pain [89]. Here, more effort is needed, to find out which facial descriptors help observers in real time to correctly identify pain in patients with different types and different degrees of dementia. Moreover, pain detection will surely improve when not only focusing on facial expression but by additionally assessing body movements and vocalization. Combining facial expression with autonomic pain indicators (e.g., heart rate) seems less promising for patients with dementia, given that autonomic responses to pain seem attenuated in patients with dementia and thus, might be less pain-indicative compared to cognitively unimpaired individuals [90].

The immense effort that has been invested in the last two decades to improve pain assessment in patients with dementia has led to a much better understanding of how facial expressions of pain can be used to assess pain in this fragile patient group. We are optimistic that many of the challenges we are still facing today will be solved in the next decades. Especially, new developments in computer imaging processing and machine learning might allow for automatic detection of pain from facial expressions in future years [91]. These approaches have only focused on facial expressions in people without dementia, and thus, it has to be seen whether they can also be used to assess facial expressions of pain in patients with dementia in daily care. Thus, using facial expressions for pain assessment purposes are a promising and newly developing research field that will surely expand in the future.

References

1. American Psychiatric Association: *Diagnostic and Statistical Manual of Mental Disorders (5th Edition)*. Arlington, VA, USA (2013).
2. Pautex S, Herrmann F, Le Lous P, Fabjan M, Michel JP, Gold G. Feasibility and reliability of four pain self-assessment scales and correlation with an observational rating scale in hospitalized elderly demented patients. *J. Gerontol. A. Biol. Sci. Med. Sci.* 60(4), 524–529 (2005).
3. Maxwell CJ, Dalby DM, Slater M, *et al*. The prevalence and management of current daily pain among older home care clients. *Pain* 138(1), 208–216 (2008).
4. Patel KV, Guralnik JM, Dansie EJ, Turk DC. Prevalence and impact of pain among older adults in the United States: findings from the 2011 National Health and Aging Trends Study. *Pain* 154(12), 2649–2657 (2013).
5. Takai Y, Yamamoto-Mitani N, Okamoto Y, Koyama K, Honda A. Literature review of pain prevalence among older residents of nursing homes. *Pain Manag. Nurs.* 11(4), 209–223 (2010).
6. Ferrell B, Casarett D, Epplin J, *et al*. The management of persistent pain in older persons. *J. Am. Geriatr. Soc.* 50: S205–S224 (2002).
7. Kunz M, Scharmann S, Hemmeter U, Schepelmann K, Lautenbacher S. The facial expression of pain in patients with dementia. *Pain* 133(1–3), 221–228 (2007). ** Important experimental study with a detailed description of facial expression of pain in patients with dementia
8. Lints-Martindale AC, Hadjistavropoulos T, Lix LM, Thorpe L. A comparative investigation of observational pain assessment tools for older adults with dementia. *Clin. J. Pain* 28(3), 226–237 (2012).

9. Sheu E, Versloot J, Nader R, Kerr D, Craig KD. Pain in the elderly: validity of facial expression components of observational measures. *Clin. J. Pain* 27(7), 593–601 (2011).* Article that discusses the importance of specific pain expressions in relation to expressions of emotional state
10. Hadjistavropoulos HD, Craig KD, Grunau RV, Johnston CC. Judging pain in newborns: facial and cry determinants. *J. Pediatr. Psychol*. 19(4), 485–491 (1994).
11. Johnson CC, Strada ME. Acute pain response in infants: a multidimensional description. *Pain* 24(3), 373–382 (1986).
12. Herr K, Bjoro K, Decker S. Tools for assessment of pain in nonverbal older adults with dementia: a state-of-the-science review. *J. Pain Symptom Manage.* 31(2), 170–192 (2006).
13. Husebo B, Achterberg WP, Lobbezoo F, *et al*. Pain in patients with dementia: A review of pain assessment and teatment challenges. *Norsk Epidemiologi* 22(2), 243–251 (2012). * Important review that gives a comprehensive overview on pain assessment in patients with dementia
14. Lobbezoo F, Weijenberg RA, Scherder EJ. Topical review: orofacial pain in dementia patients. A diagnostic challenge. *J. Orofac. Pain* 25(1), 6–14 (2011).
15. Lord B. Paramedic assessment of pain in the cognitively impaired adult patient. *BMC Emerg. Med.* 9, 20 (2009).
16. Park J, Castellanos-Brown K, Belcher J. A Review of Observational Pain Scales in Nonverbal Elderly With Cognitive Impairments. *Res. Soc. Work. Pract.* 20(6), 651–664 (2010).
17. Stolee P, Hillier LM, Esbaugh J, Bol N, McKellar L, Gauthier N. Instruments for the assessment of pain in older persons with cognitive impairment. *J. Am. Geriatr. Soc.*

53(2), 319–326 (2005).

18. van Herk R, van Dijk M, Baar FP, Tibboel D, de Wit R. Observation scales for pain assessment in older adults with cognitive impairments or communication difficulties. *Nurs. Res.* 56(1), 34–43 (2007).
19. Zwakhalen SM, Hamers JP, Abu-Saad HH, Berger MP. Pain in elderly people with severe dementia: a systematic review of behavioural pain assessment tools. *BMC Geriatr.* 6, 3 (2006). ** The key review article on behavioural pain asessment tools
20. Abbey J, Piller N, De Bellis A, *et al*. The Abbey pain scale: a 1-minute numerical indicator for people with end-stage dementia. *Int. J. Palliat. Nurs.* 10(1), 6–13 (2004).
21. Cohen-Mansfield J. Pain Assessment in Noncommunicative Elderly persons--PAINE. *Clin. J. Pain* 22(6), 569–575 (2006).
22. Feldt KS. The checklist of nonverbal pain indicators (CNPI). *Pain Manag. Nurs.* 1(1), 13–21 (2000).
23. Fuchs-Lacelle S, Hadjistavropoulos T. Development and preliminary validation of the pain assessment checklist for seniors with limited ability to communicate (PACSLAC). *Pain Manag. Nurs.* 5(1), 37–49 (2004).
24. Husebo BS, Strand LI, Moe-Nilssen R, Husebo SB, Snow AL, Ljunggren AE. Mobilization-Observation-Behavior-Intensity-Dementia Pain Scale (MOBID): development and validation of a nurse-administered pain assessment tool for use in dementia. *J. Pain Symptom Manage.* 34(1), 67–80 (2007).
25. Husebo BS, Strand LI, Moe-Nilssen R, Husebo SB, Ljunggren AE. Pain in older persons with severe dementia. Psychometric properties of the Mobilization-Observation-Behaviour-Intensity-Dementia (MOBID-2) Pain Scale in a clinical setting. *Scand. J. Caring Sci.* 24(2), 380–391 (2010).

26. Hurley AC, Volicer BJ, Hanrahan P, *et al*. Assessment of discomfort in advanced Alzheimer patients. *Res. Nurs. Health* 15(5), 369–377 (1992).

27. Kovach CR, Weissman DE, Griffie J, Matson S, Muchka S. Assessment and treatment of discomfort for people with late-stage dementia. *J. Pain Symptom Manage.* 18(6), 412–419 (1999).

28. Morello R, Jean A, Alix M, Sellin-Peres D, Fermanian J. A scale to measure pain in non-verbally communicating older patients: the EPCA-2 Study of its psychometric properties. *Pain* 133(1–3), 87–98 (2007).

29. Snow AL, Weber JB, O'Malley KJ, *et al*. NOPPAIN: a nursing assistant-administered pain assessment instrument for use in dementia. *Dement. Geriatr. Cogn. Dis.* 17(3), 240–246.(2004).

30. Villanueva MR, Smith TL, Erickson JS, Lee AC, Singer CM. Pain Assessment for the Dementing Elderly (PADE): reliability and validity of a new measure. *J. Am. Med. Dir. Assoc.* 4(1), 1–8 (2003).

31. Warden V, Hurley AC, Volicer L. Development and psychometric evaluation of the Pain Assessment in Advanced Dementia (PAINAD) scale. *J. Am. Med. Dir. Assoc.*4(1), 9–15 (2003).

32. Wary B, Doloplus C. [Doloplus-2, a scale for pain measurement]. *Soins Gerontol.* 19, 25–27 (1999).

33. Lints-Martindale MA, Hadjistavropoulos t., Barber B. Gibson SJ. A Psychophysical Investigation of the Facial Action Coding System as an Index of Pain Variability among Older Adults with and without Alzheimer's Disease. *Pain Med.* 8(8), 678–689 (2007)

34. Prkachin KM. The consistency of facial expressions of pain: a comparison across modalities. *Pain* 51(3), 297–306 (1992).** Important study that describes which facial

movements occur when individuals are experiencing pain

35. Beach PA, Huck JT, Miranda MM, Foley KT, Bozoki AC. Effects of Alzheimer's Disease on the Facial Expression of Pain. *Clin. J. Pain* in press.
36. Hadjistavropoulos T, LaChapelle DL, Hadjistavropoulos HD, Green S, Asmundson GJ. Using facial expressions to assess musculoskeletal pain in older persons. *Eur. J. Pain* 6(3), 179–187 (2002).
37. Hadjistavropoulos T, Craig KD, Duck S, *et al*. A biopsychosocial formulation of pain communication. *Psychol. Bull.* 137(6), 910–939 (2011).
38. Kunz M, Mylius V, Schepelmann K, Lautenbacher S. On the relationship between self-report and facial expression of pain. *J. Pain* 5(7), 368–376 (2004).
39. Craig KD, Prkachin KM, Grunau RE. The facial expression of pain. In: *Handbook of Pain Assessment(2nd Edition).* DCTurk, R Melzack (Ed.) The Guilford Press, New York, USA, 117–133 (2001).
40. Kunz M, Chen JI, Lautenbacher S, Vachon-Presseau E, Rainville P. Cerebral regulation of facial expressions of pain. *J. Neurosci.* 31(24), 8730–8738 (2011).
41. Smith M. Pain assessment in nonverbal older adults with advanced dementia. *Perspect. Psychiatr. Care* 41(3), 99–113 (2005).
42. Kunz M, Mylius V, Schepelmann K, Lautenbacher S. Effects of age and mild cognitive impairment on the pain response system. *Gerontology* 55(6), 674–682 (2009).
43. Klein-Koerkamp Y, Beaudoin M, Baciu M, Hot P. Emotional decoding abilities in Alzheimer's disease: a meta-analysis. *J. Alzheimers Dis.* 32(1), 109–125 (2012).
44. Borsje P, Wetzels RB, Lucassen PL, Pot AM, Koopmans RT. The course of neuropsychiatric symptoms in community-dwelling patients with dementia: a systematic review. *Int. Psychogeriatr.* 27(3), 385–405 (2015).

45. Kaasalainen S., Akhtar-Danesh N., Hadjistavropoulos T., Zwakhalen S., Vereault R. A Comparison Between Behavioral and Verbal Report Pain Assessment Tools for Use with Residents in Long Term Care. *Pain Manag. Nurs.* 14(4), 106–114 (2013).
46. Manfredi PL, Breuer B, Meier DE, Libow L. Pain assessment in elderly patients with severe dementia. *J. Pain Symptom Manage.* 25(1), 48–52 (2003).
47. van der Steen JT, Sampson EL, Van den Block L, *et al*. Tools to Assess Pain or Lack of Comfort in Dementia: A Content Analysis. *J. Pain Symptom Manage.* 50(5), 659–675 (2015).
48. Borroni B, Cosseddu M, Pilotto A, *et al*. Early stage of behavioral variant frontotemporal dementia: clinical and neuroimaging correlates. *Neurobiol. Aging.* 36(11), 3108–3115 (2015).
49. Jost BC, Grossberg GT. The evolution of psychiatric symptoms in Alzheimer's disease: a natural history study. *J. Am. Geriatr. Soc.* 44(9), 1078–1081 (1996).
50. Spalletta G, Musicco M, Padovani A, *et al.* Neuropsychiatric symptoms and syndromes in a large cohort of newly diagnosed, untreated patients with Alzheimer disease. *Am. J. Geriatr. Psychiatry* 18(11), 1026–1035 (2010).
51. McKhann GM, Knopman DS, Chertkow H, *et al.* The diagnosis of dementia due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers Dement.* 7(3):263–269 (2011).
52. Rosen HJ, Allison SC, Schauer GF, Gorno-Tempini ML, Weiner MW, Miller BL. Neuroanatomical correlates of behavioural disorders in dementia. *Brain* 128(Pt 11), 2612–2625 (2005).
53. Rosenberg PB, Nowrangi MA, Lyketsos CG. Neuropsychiatric symptoms in Alzheimer's

disease: What might be associated brain circuits? *Mol. Aspects Med*. 43–44, 25–37 (2015).

54. Goodkind MS, Gyurak A, McCarthy M, Miller BL, Levenson RW. Emotion regulation deficits in frontotemporal lobar degeneration and Alzheimer's disease. *Psychol. Aging* 25(1), 30–37 (2010). * Article in which voluntary control of facial expressions in diverse dementia subtypes is described
55. Smith MC. Facial expression in mild dementia of the Alzheimer type. *Behav. Neurol.* 8(3–4), 149–156 (1995).
56. Henry JD, Rendell PG, Scicluna A, Jackson M, Phillips LH. Emotion experience, expression, and regulation in Alzheimer's disease. *Psychol. Aging* 24(1), 252–257 (2009).
57. Mograbi DC, Brown RG, Morris RG. Emotional reactivity to film material in Alzheimer's disease. *Dement. Geriatr. Cogn. Disord*. 34(5–6), 351–359 (2012).
58. Ross ED. Facial expressions, pain and nociception--are they related? *Nat. Clin. Pract. Neurol.* 4(6), 304–305 (2008).
59. Karmann AJ, Lautenbacher S, Kunz M. The role of inhibitory mechanisms in the regulation of facial expressiveness during pain. *Biol. Psychol.* 104, 82–89 (2015).
60. Oosterman JM, Traxler J, Kunz M. The Influence of Executive Functioning on Facial Pain Expression and Subjective Pain Report. *Unpublished data.*
61. Mega MS, Cummings JL, Fiorello T, Gornbein J. The spectrum of behavioral changes in Alzheimer's disease. *Neurology* 46(1), 130–135 (1996).
62. Bruen PD, McGeown WJ, Shanks MF, Venneri A. Neuroanatomical correlates of neuropsychiatric symptoms in Alzheimer's disease. *Brain* 131(Pt 9), 2455–2463 (2008).
63. Stella F, Radanovic M, Aprahamian I, Canineu PR, de Andrade LP, Forlenza OV. Neurobiological correlates of apathy in Alzheimer's disease and mild cognitive

impairment: a critical review. *J. Alzheimers Dis.* 39(3), 633–648 (2014).

64. Husebo BS, Ballard C, Fritze F, Sandvik RK, Aarsland D. Efficacy of pain treatment on mood syndrome in patients with dementia: a randomized clinical trial. *Int. J. Geriatr. Psychiatry* 29(8), 828–836 (2014).
65. van Dalen-Kok AH, Pieper MJ, de Waal MW, Lukas A, Husebo BS, Achterberg WP. Association between pain, neuropsychiatric symptoms, and physical function in dementia: a systematic review and meta-analysis. *BMC Geriatr.* 15, 49 (2015).
66. Husebo BS, Ballard C, Sandvik R, Nilsen OB, Aarsland D. Efficacy of treating pain to reduce behavioural disturbances in residents of nursing homes with dementia: cluster randomised clinical trial. *BMJ* 343, d4065 (2011). ** Important proof of concept study demonstrating how treating pain in people with dementia may decrease agitation
67. Husebo BS, Ballard C, Cohen-Mansfield J, Seifert R, Aarsland D. The response of agitated behavior to pain management in persons with dementia. *Am. J. Geriatr. Psychiatry* 22(7), 708–717 (2014).
68. Snowden JS, Bathgate D, Varma A, *et al*. Distinct behavioural profiles in frontotemporal dementia and semantic dementia. *J. Neurol. Neurosurg. Psychiatry* 70, 323–332 (2001).
69. Snowden JS, Neary D, Mann DMA. Frontotemporal Lobar Degeneration: Frontotemporal Dementia, Progressive Aphasia, Semantic Dementia. Churchill Livingstone, New York, NY (1996).
70. Oosterman JM, Hendriks H, Scott S, Lord K, White N, Sampson EL. When pain memories are lost: a pilot study of semantic knowledge of pain in dementia. *Pain Med.* 15(5), 751–757 (2014).
71. Fletcher PD, Downey LE, Golden HL, *et al*. Pain and temperature processing in dementia: a clinical and neuroanatomical analysis. *Brain* 138(Pt 11), 3360–3372 (2015).

72. Scherder EJ, Slaets J, Deijen JB, *et al*. Pain assessment in patients with possible vascular dementia. *Psychiatry* 66(2), 133–145 (2003).

73. Scherder EJ, Plooij B, Achterberg WP, *et al*. Chronic pain in "probable" vascular dementia: preliminary findings. *Pain Med.* 16(3), 442–350 (2015).

74. Bathgate D, Snowden JS, Varma A, Blackshaw A, Neary D. Behaviour in frontotemporal dementia, Alzheimer's disease and vascular dementia. *Acta Neurol. Scand.* 103(6), 367–378 (2001).

75. Carlino E, Benedetti F, Rainero I, *et al*. Pain perception and tolerance in patients with frontotemporal dementia. *Pain* 151(3), 783–789 (2010).

76. Defrin R, Amanzio M, de Tommaso M, *et al*. Experimental pain processing in individuals with cognitive impairment: current state of the science. *Pain* 156(8), 1396–1408 (2015).

77. Achterberg WP, Pieper MJ, van Dalen-Kok AH, *et al*. Pain management in patients with dementia. *Clin. Interv. Aging* 8, 1471–1482 (2013).

78. Lautenbacher S, Niewelt BG, Kunz M. Decoding pain from the facial display of patients with dementia: a comparison of professional and nonprofessional observers. *Pain Med.* 14(4), 469–477 (2013).

79. Kappesser J, Williams AC, Prkachin KM. Testing two accounts of pain underestimation. *Pain* 124(1–2), 109–116 (2006). * Article demonstrating that professional observers may underestimate pain when solely relying on facial expressions

80. Prkachin KM, Solomon PE, Ross J. Underestimation of pain by health-care providers: towards a model of the process of inferring pain in others. *Can. J. Nurs. Res.* 39(2), 88–106 (2007).

81. Herr K, Coyne PJ, Key T, *et al*. Pain assessment in the nonverbal patient: position statement with clinical practice recommendations. *Pain Manag. Nurs*. 7(2), 44–52 (2006).

82. Colamonico J, Formella A, Bradley W. Pseudobulbar affect: burden of illness in the USA. *Adv. Ther*. 29(9), 775–798 (2012).

83. Work SS, Colamonico JA, Bradley WG, Kaye RE. Pseudobulbar affect: an under-recognized and under-treated neurological disorder. *Adv. Ther.* 28(7), 586–601 (2011).

84. Aarsland D, Ballard C, McKeith I, Perry RH, Larsen JP. Comparison of extrapyramidal signs in dementia with Lewy bodies and Parkinson's disease. *J. Neuropsychiatry Clin. Neurosci.* 13(3), 374–379 (2001).

85. McKeith I. Dementia with Lewy bodies. *Dialogues Clin. Neurosci.* 6(3), 333–341 (2004).

86. Priebe JA, Kunz M, Morcinek C, Rieckmann P, Lautenbacher S. Does Parkinson's disease lead to alterations in the facial expression of pain? *J. Neurol. Sci.* 359(1–2), 226–235 (2015).

87. Herr K, Coyne PJ, McCaffery M, Manworren R, Merkel S. Pain assessment in the patient unable to self-report: position statement with clinical practice recommendations. *Pain Manag. Nurs.* 12(4), 230–250 (2011).

88. Wood S, Cummings JL, Hsu MA, *et al*. The use of the neuropsychiatric inventory in nursing home residents. Characterization and measurement. *Am. J. Geriatr. Psychiatry* 8(1), 75–83 (2000).

89. Stroop JR. Studies of interference in serial verbal reactions. *J. Exp. Psychol.* 18(6), 643–662 (1935).

90. Roy C, Blais C, Fiset D, Rainville P, Gosselin F. Efficient information for recognizing pain in facial expressions. *Eur. J. Pain* 19(6), 852–860 (2015).

91. Kunz M, Mylius V, Scharmann S, Schepelman K, Lautenbacher S. Influence of dementia on multiple components of pain. *Eur. J. Pain* 13(3), 317–325 (2009).

92. Bartlett MS, Littlewort GC, Frank MG, Lee K. Automatic decoding of facial movements

reveals deceptive pain expressions. *Curr. Biol.* 24(7), 738–743 (2014).

Financial disclosure

The authors declare that there is no conflict of interest regarding the publication of this paper.

Most common used observational scales	**Descriptions of facial expressions indicative of pain extracted from the scales listed in the left column**
ABBEY Pain Scale [20]	Absent
ADD [27]	Blinking
CNPI [22]	Change in eyes (squinting, dull, bright, increased movement)
DS-DAT [26]	Clenched teeth
DOLOPLUS-2 [32]	Closing eyes
EPCA [28]	Creasing forehead
MOBID-2 Pain Scale [24,25]	Disinterested
NOPPAIN [29]	Dirty look
PACSLAC [23]	Distorted expressions
PADE [30]	Drawn, atonic fixed gaze
PAINAD [31]	Empty gaze
PAINE [21]	Looking frightened*
	Frowning*
	Furrowed brow*
	Grimacing*
	Jaw drop
	Looking tense*
	Narrowed eyes*
	Eyes wide opened
	Opening mouth
	Pain expression*
	Pale Face
	Rigid Expression

Quivering chin
Looking sad
Screwing up nose
Teary eyed
Tightened lips
Tighter face
Wincing
Looking worried*
Withdrawn

Table 1. The facial expression items incorporated in the most commonly-used observation scales

* these items are used most frequently

ADD: Assessment of Discomfort in Dementia; CNPI: Checklist of Nonverbal Pain Indicators; DS-DAT: Discomfort Scale-Dementia Alzheimer Type; EPCA: Elderly Pain Caring Assessment; MOBID: Mobilization-Observation-Behavior-Intensity-Dementia Pain Scale; NOPPAIN: Non-Communicating Patient's Pain Assessment Instrument; PACSLAC: Pain Assessment Checklist for Seniors with Limited Ability to Communicate; PADE: Pain Assessment in Dementing Elders; PAINAD: Pain Assessment in Advanced Dementia Scale; PAINE: Pain Assessment in Noncommunicative Elderly Persons.

Supplementary online Table. Overview of the most common reviewed pain observation tools and the facial expression items they contain

Pain scale	**Total number of items and scoring format**	**Number of facial expressions/total number of behaviors**	**Specification of facial expressions included in tool**
The Abbey Pain Scale[1]	6 categorical items in total scored on a 4-point scale (0= Absent- 3= severe). Total score range from 0-18.	1/6	Facial expression Specified as e.g., looking tense, frowning, grimacing, looking frightened.
Checklist of Nonverbal Pain Indicators (CNPI)[2]	6 items scored present or absent at rest and movement Total score range from 0-12.	1/6	Facial grimacing or wincing.
Doloplus-2 [3]	10 items (3 dimensions) in total scored on a 3-point scale Total score range from 0-30.	1/10	Expression. Specified in lexicon as 'The facial expression appears to express pain (grimaces, drawn, atonic) as does the gaze (fixed gaze, empty gaze, absent, tears)' .
Elderly Pain Caring Assessment (EPCA- 2)[4]	2 subscales (signs outside caregiving, signs during caregiving) of 4 categorical	1/8	Facial expression Scored as

Pain scale	Total number of items and scoring format	Number of facial expressions/total number of behaviors	Specification of facial expressions included in tool
	items scored on a 5-point scale (0=no pain - 4=extremely intense pain). Total score range from 0-32.		0: Relaxed look on the face 1: Anxious look on the face 2: Patient grimaces from time to time 3: Frightened look and/or tense facial expression 4: Totally rigid expression
Mobilization-Observation-Behavior-Intensity-Dementia Pain Scale (MOBID)[5,6]	3 behavioral items are scored on a 0-10 point NRS during guided movement	1/3	Facial expression Specified as grimacing, frowning, tightening mouth, closing eyes.
Non-Communicating Patient's Pain Assessment Instrument (NOPPAIN)[7]	One of the 4 parts of the tool contains 6 items. Items are scored as yes/no and in addition on a 6-point scale (0 lowest possible intensity- 5 highest possible intensity).		Pain faces? Specified as grimaces, furrowed brow, winces.
Pain Assessment Checklist for Seniors with Limited Ability to Communicate (PACSLAC)[8]	60 item checklist Total score range from 0-60	13/60	Facial expressions: Grimacing Sad look Tighter face Dirty look

Pain scale	**Total number of items and scoring format**	**Number of facial expressions/total number of behaviors**	**Specification of facial expressions included in tool**
			Changes in eyes Frowning Pain expression Grim face Clenching teeth Wincing Opening mouth Creasing forehead Screwing up nose
Pain Assessment in Dementing Elders (PADE)[9]	Tool has 3 parts and contains 13 items scored on a 1-4 scale (0= none- 4 extreme).	4/13	Does the resident have a "sad" facial expression? Does the resident have an "anxious / frightened" facial expression? Is the resident frowning? During transfers does the resident grimace, brace him/ herself, groan etc?
The Pain Assessment in Advanced Dementia Scale (PAINAD)[10]	5 categorical items scored on a 2 point scale	1/5	Facial expression Scored as

Pain scale	**Total number of items and scoring format**	**Number of facial expressions/total number of behaviors**	**Specification of facial expressions included in tool**
	Total score range from 0-10.		0= Smiling or inexpressive 1= Sad, frightened or frown 2= Facial grimacing
Pain Assessment in Noncommunicative Elderly Persons (PAINE)[11]	22 item in total scored on a 6-point scale (1=never- 7= several times an hour).	1/22	Facial grimaces. Specified as showing tension in the face – frowning, tightening the eyes, squinting, clenching or grinding teeth.

References

1. Abbey J, Piller N, De Bellis A, *et al*. The Abbey pain scale: a 1-minute numerical indicator for people with end-stage dementia. *Int. J. Palliat. Nurs.* 10(1), 6–13 (2004).
2. Feldt KS. The checklist of nonverbal pain indicators (CNPI). *Pain Manag. Nurs.* 1(1), 13–21 (2000).
3. Wary B, Doloplus C. [Doloplus-2, a scale for pain measurement]. Soins Gerontol. 19, 25–27 (1999).
4. Morello R, Jean A, Alix M, Sellin-Peres D, Fermanian J. A scale to measure pain in non-verbally communicating older patients: the EPCA-2 Study of its psychometric properties. *Pain* 133(1–3), 87–98 (2007).
5. Husebo BS, Strand LI, Moe-Nilssen R, Husebo SB, Ljunggren AE. Pain in older persons with severe dementia. Psychometric properties of the Mobilization-Observation-Behaviour-

Intensity-Dementia (MOBID-2) Pain Scale in a clinical setting. *Scand. J. Caring Sci.* 24(2), 380–391 (2010).

6. Husebo BS, Strand LI, Moe-Nilssen R, Husebo SB, Snow AL, Ljunggren AE. Mobilization-Observation-Behavior-Intensity-Dementia Pain Scale (MOBID): development and validation of a nurse-administered pain assessment tool for use in dementia. *J. Pain Symptom Manage.* 34(1), 67–80 (2007).
7. Snow AL, Weber JB, O'Malley KJ, *et al*. NOPPAIN: a nursing assistant-administered pain assessment instrument for use in dementia. *Dement. Geriatr. Cogn. Dis.* 17(3), 240–246.(2004).
8. Fuchs-Lacelle S, Hadjistavropoulos T. Development and preliminary validation of the pain assessment checklist for seniors with limited ability to communicate (PACSLAC). *Pain Manag. Nurs.* 5(1), 37–49 (2004).
9. Villanueva MR, Smith TL, Erickson JS, Lee AC, Singer CM. Pain Assessment for the Dementing Elderly (PADE): reliability and validity of a new measure. *J. Am. Med. Dir. Assoc.* 4(1), 1–8 (2003).
10. Warden V, Hurley AC, Volicer L. Development and psychometric evaluation of the Pain Assessment in Advanced Dementia (PAINAD) scale. *J. Am. Med. Dir. Assoc.*4(1), 9–15 (2003).
11. Cohen-Mansfield J. Pain Assessment in Noncommunicative Elderly persons--PAINE. *Clin. J. Pain* 22(6), 569–575 (2006).

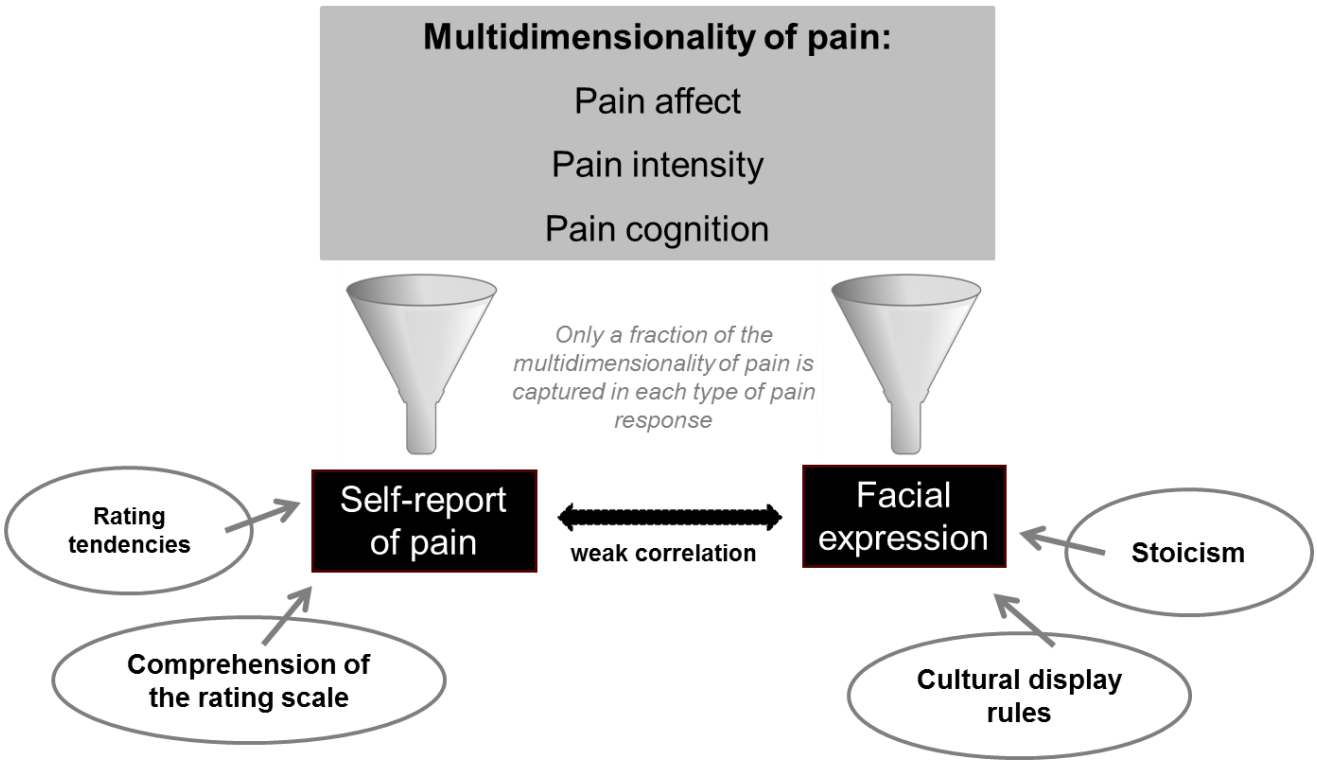

Figure 1: An illustration of the multidimensionality of pain.