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Impact of age on the facial expression of pain

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Abstract

Objective: Old age has traditionally been viewed as being associated with a decline in emotional expressivity. Interestingly, empirical evidence based on analyses of facial expressions contradicts this traditionally view and points to absence of (or only very slight) age-related changes in emotional expressivity. However, this research on emotional expressivity in older persons has neglected one important emotionally colored state—expression of pain. In order to close this gap, we aimed to investigate the influence of age on the facial expression of pain. **Methods:** Forty young (mean age, 24.1 years) and 61 elderly (mean age, 72.3 years) subjects were investigated for their facial (Facial Action Coding System) and subjective responses to noxious mechanical and electrical stimuli of various intensities. **Results:** Young and elderly subjects did not differ with respect to the frequency of facial responses during noxious mechanical and electrical stimulations. Moreover, age had no significant impact on the pain specificity of these facial responses. Furthermore, we found no significant age differences in self-report ratings of pressure and electrical pain, thus indicating that both age groups experienced comparable amounts of pain intensities. **Conclusion:** These findings suggest that the facial expression of pain, like facial expressions of other affective states, remains unchanged in older persons. Consequently, elderly individuals seem to communicate pain through their facial expression as validly as younger individuals do.

Keywords: Age; Emotional expressivity; Facial expression; Pain

Introduction

Old age has traditionally been viewed as being associated with a decline in emotion-expressive behavior [1,2], with elderly individuals being believed to show less frequent and less intense emotional expressions.

In accordance with this traditional view, the majority of findings of studies based on self-evaluation suggest a decline in emotional expressivity with age [3–5]. Elderly subjects were more likely to endorse statements such as "Whether I am happy or sad inside, I look pretty much the same" than were younger subjects. The interpretation of these results, however, is limited in so far as these studies relied mainly on self-evaluation measures of emotional expressivity. Since emotional expressivity has been defined as behavioral change that usually accompanies emotion [6], research including behavioral measures of emotional responses may provide more objective and valid measures of emotional expressivity than those research involving only self-evaluation.

As a behavioral measure of emotional response, facial expressions during elicited emotions (happiness, sadness, anger, and so on) were assessed in the majority of studies on age-related changes in emotional expressivity. Emotions were typically elicited by a relived emotions task or by using a film-based emotion induction. In most of these cross-sectional studies, no significant age effects on elicited facial responses were found [7–10]. The frequency and intensity of facial expressions of various emotions were comparable in young and elderly subjects. Only the findings of one study,

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where facial expressions of married couples were analyzed during a discussion of marital problems, pointed to an age-related decrease in facial expressions, with elderly subjects displaying less anger and disgust compared to younger subjects [11]. However, the age differences found were only small. Thus, the majority of empirical evidence based on behavioral measures of facial expression suggests that emotion-expressive behavior does not seem to decline in older persons, but that elderly individuals show the same capacity to express their emotions through facial responses.

Although the abovementioned studies have yielded important results regarding the impact of age on the expression of various emotions, the facial expression of pain, which is thought to have a strong emotional component, has not been investigated so far for age-related differences. Since there are several reasons for being interested in this topic, the neglect might appear surprising.

First of all, it seems very likely that age has an effect on the facial expression of pain. Pain is strongly associated with age, with pain prevalence increasing among elderly individuals [12]. This age-related increase in pain prevalence could suggest, on one hand, more practice and more reasons to signal pain by behavioral expressions. On the other hand, pain is considered an inevitable accompanist of advanced age, which does not seem worth mentioning and showing [13]. Accordingly, it can be expected that the facial expression of pain will be affected by the age-related increase in pain prevalence, although the direction of change is unclear. Another reason for studying the influence of age on the facial expression of pain is the great practical importance of facial expressions in the assessment of pain. It has been shown that the facial expression of pain is a reliable nonverbal pain indicator that plays a decisive role when judging another person's pain [14,15]. However, it is not known whether this is also applicable to the facial expression of pain in elderly individuals. Do elderly individuals communicate pain through their facial expression as validly and reliably as younger individuals do?

So far, empirical evidence on age-related changes in behavioral expressions of pain has been very scarce. Yong et al. [16], who investigated age differences in pain attitude (stoicism), reported that elderly subjects rated themselves as being more reluctant to show their pain to others compared to younger subjects (e.g., "I keep a 'stiff upper lip' when I am in pain"). However, these findings are only based on self-evaluation, and no behavioral measures of pain expressivity were taken. Moreover, research has been conducted on observers' impressions of pain severity when looking at the faces of young and elderly patients who were undergoing painful medical procedures [17,18]. Hadjistavropoulos et al. [17] reported that elderly patients (compared to younger patients) were perceived as experiencing more pain. However, it remains unclear whether the perception of more pain in elderly patients was due to objective changes in facial expressions or to stereotypes held by the observers. Thus, although some tentative findings regarding the relationship between age and the expression of pain have been reported, a systematic investigation of the behavioral expression of pain in older persons is still lacking.

In order to close this gap in the present cross-sectional study, we aimed to investigate the association of age with the facial expression of pain. Facial expression was quantified with the use of the Facial Action Coding System (FACS), which anatomizes facial action into single muscle movements. Specific clusters of these muscle movements have been repeatedly observed in situations associated with pain [19]. We were interested in two aspects: (a) whether there are age-related differences in the frequency and intensity of occurrence of these clusters of muscle movement during noxious stimulation (expressivity), and (b) whether age influences the specificity of activation of these clusters (specificity). Specificity of facial expression can be assumed if these clusters of muscle movement, but not the entire repertoire of muscle movements, are selectively activated during pain. Since empirical evidence on the influence of age on the facial expression of pain is scarce, it was not possible to deduce directed hypotheses. We assessed facial responses during noxious stimulation (electrical current and pressure) in young and elderly subjects. Additionally, we assessed self-report ratings of pain intensity.

Materials and methods

Subjects

Forty (♀, 20; ♂, 20) young subjects between the ages of 20 and 38 years (mean age, 24.1±3.2 years) and 61 (♀, 48; ♂, 13) elderly subjects[1] between the ages of 65 and 85 years (mean age, 72.3±5.6 years) participated in this study. The young subjects were recruited via advertisements posted in university buildings, whereas the elderly subjects were recruited among students of the Senior University at the University of Marburg. None had taken any analgesic medication for at least 24 h prior to the test session. Participants with any condition that could affect pain perception and pain report, such as diabetes, hypertension, peripheral and central neuropathy, and neurological and psychiatric disorders, were excluded from the study. A special focus was the reliable exclusion of elderly individuals with dementia. Prior to the experiment, a thorough neuropsychological and neurological examination [including testing of the cognitive (Mini Mental State Examination, Trail Making) and affective status (Geriatric Depression Scale), screening for psychiatric disorders (Short Interview for Psychiatric Disorders, MINI-DIPS), examination of the somatosensory system, testing of deep-tendon reflexes, autonomic testing, sural neurography, and so on] was

[1] All 61 elderly subjects completed the first block of pressure stimulation, whereas this number dropped to 51 during the second block of electrical stimulation.

conducted in order to identify persons who meet the exclusion criteria. The study protocol was approved by the ethics committee of the medical faculty of the University of Marburg. All subjects were paid for their participation and gave written informed consent.

Materials and procedure

Experimental pain was induced by using two types of physical stimuli: mechanical and electrical. All testings were conducted from 1500 to 1830 h and lasted for approximately 2 h. The testing procedure included examination of potential exclusion criteria (approximately 1 h), application of pressure stimuli (20 min), a short break (10 min), and application of electrical stimuli (30 min). All subjects were seated in an armchair after physical examination.

Mechanical stimuli

A Fischer algometer (a force gauge fitted with a rubber disk with a surface of 1 cm^2) was used to assess responses to noxious mechanical pressure [20]. The algometer was slightly modified so that each stimulus onset could be electronically recorded and could be used as a trigger signal for video analysis.

In order to familiarize subjects with pressure stimulation, three stimuli of 2–3 kg ("kg" is used as a physical unit in the present study because the Fischer algometer is scaled in the same manner) were applied to the thigh before the tests started. During the test, 20 stimuli varying between 1 and 5 kg (4 stimuli at each intensity) were applied to the right and left forearms in random order, which had been determined once and was used for all subjects. Pressure was increased steadily at an application rate of 1 kg/s until maximum stimulus intensity had been reached and was then continued at that level for another 5 s. The interval between stimulus applications varied between 20 and 30 s. Pressure application was always performed by the same experimenter, who had been trained in using the Fischer algometer.

Electrical stimuli

The assessment of self-reports and facial responses to electrical stimuli was part of an assessment battery for multidimensional pain responses, including the nociceptive flexion reflex, heart rate responses, and sympathetic skin responses. These physiological data are not reported here. Electrical stimulation was especially designed to determine the threshold of the flexion reflex and the suprathreshold reflex responses (in accordance with the protocol of France et al. [21] and Mylius et al. [22]). For electrical stimulation, a surface electrode was attached over the sural nerve at the backside of the lower leg. The stimulus consisted of a train of five rectangular impulses (1 ms duration) at a frequency of 250 Hz (Viking IV D; Nicolet Biomedical). To familiarize the subjects with electrical stimulation, we chose stimuli of very mild intensities for use at the beginning. Stimulus intervals varied between 20 and 30 s.

First, the R-III reflex threshold was determined using an up–down staircase method [21]. For that purpose, stimulation intensity was increased in 3-mA steps until the flexion reflex had been detected for the first time [22], and was then decreased in 2-mA steps until the reflex had again disappeared. After that, steps of 1 mA were used, and the procedure was continued until the reflex had appeared and subsided two more times. The mean scores of all three peaks and troughs (in milliamperes) determined the reflex threshold.

Immediately following this threshold assessment protocol, a series of 10 stimuli 5 mA above the reflex threshold was delivered.

Facial expression of pain

The face of the subject was videotaped throughout the entire session. The camera was placed in front of the subject at a distance of approximately 4 m. Before the application of a stimulus, subjects were instructed to focus on an emotionally neutral picture positioned behind the camera in order to ensure a frontal view of the face. Subjects were also instructed not to talk during pain induction. To mark the onset of pain stimulation on the videotape (for further analysis), we switched on a signal light concurrently. The light was visible to the camera, but not to the subject.

FACS [23] was used to analyze facial responses. It is based on an anatomical analysis of facial muscle movements and distinguishes 44 different action units (AUs). This is the minimal number of units of facial activities that are anatomically separate and visually distinguishable. The intensity for each AU was rated on a 5-point scale (A–E). A FACS coder (who qualified by passing an examination given by the developers of the system by reaching an interrater reliability of >.80) identified the frequency of all 44 AUs and the intensity of 42 AUs (AUs 45 and 46 do not allow for intensity coding). As regards the present set of data, the FACS coder achieved an intrarater reliability of between .84 and .98 in a subsample of subjects for AUs 6 and 7, which are known for their pain relevance.[2] A special software designed for analysis of observational data (the Observer Video-Pro; Noldus Information Technology) was used to segment the videos and to enter the FACS codes into a time-related database. Time segments of 5 s beginning just after the stimulus had reached maximum were selected for scoring. In total, 20 segments of pressure stimulation (four series of pressure stimuli from 1 to 5 kg) plus 14 segments of electrical stimulation (the last 2 stimuli just below the reflex threshold, the last 2 stimuli just above the reflex threshold, and 10 stimuli 5 mA above the threshold)

[2] Even this small-scale assessment of intrarater reliability took 15 h, ruling out full-scale evaluation.

Table 1
Facial AUs that occurred in at least 5% of the pain/noxious segments recorded in the groups of young and older subjects

			Younger subjects		Older subjects	
	AU	Description	Percentage [a]	Effect size (ε)	Percentage [a]	Effect size (ε)
Pressure stimulation	1/2	Brow raised	14.1	**0.60**	7.7	0.00
	4 [b]	Brow lower [b]	10.3	**1.00**	16.2	**0.85**
	6/7 [b]	Orbit tightening [b]	23.3	**1.40**	29.9	**0.72**
	9/10 [b]	Levator contraction [b]	9.2	**0.73**	9.1	**0.51**
	12	Lip-corner pull	14.9	**0.58**	<5	0.00
	17	Chin raise	7.0	0.27	<5	0.19
	25/26/27	Mouth opening	11.8	0.23	8.3	0.09
	45 [c]	Blink	215.7	0.14	297.5	0.18
Electrical stimulation	1/2	Brow raised	17.9	0.29	13.9	0.19
	4	Brow lower	17.5	0.25	18.8	0.18
	6/7 [b]	Orbit tightening [b]	49.2	**0.61**	49.2	**0.51**
	9/10 [b]	Levator contraction [b]	19.0	**0.52**	10.0	**2.08**
	12	Lip-corner pull	19.2	0.47	8.7	0.00
	14	Dimpler	10.8	0.27	6.1	0.21
	17	Chin raise	11.9	0.00	14.5	0.00
	25/26/27	Mouth opening	33.8	**0.68**	22.2	0.11
	45 [b, c]	Blink [b]	277.5	**0.65**	321.9	**0.54**

The percentages of the frequency of occurrence and the effect sizes for the difference between pain/noxious and nonpainful/nonnoxious segments are given separately for both subject groups.
Medium and strong effect sizes (ε≥0.5) are marked in boldface.

[a] Percentage denotes the percentage of occurrence in the entire pain/noxious segments.
[b] AUs that were consistently more frequent (ε≥0.5) during pain/noxious segments in both age groups.
[c] Blinking of the eye can appear more than once in a time segment of 5 s.

were analyzed. For necessary data reduction, we combined those AUs that represent facial movements of the same muscle, as has been performed in preceding studies without any loss of information (e.g., Refs. [19,24,25]). Therefore, AUs 1 and 2, AUs 6 and 7, AUs 9 and 10, and AUs 25, 26, and 27 were combined to form new variables.

To select those AUs that were pain relevant in the present experimental contexts and to summarize these facial responses to composite scores, several steps were necessary:

1. As has been performed in earlier studies (e.g., Refs. [25–28]), we denominated as pain relevant only those AUs that occurred in at least 5% of the pain/noxious segments[3] recorded. We did this separately for pressure and electrical stimulations, and separately for young and older subjects. These AUs are listed in Table 1.
2. To determine which of these AUs listed in Table 1 were critically more frequent during pain/noxious segments than during nonpainful/nonnoxious segments, we computed the effect sizes (ε) for these differences. Effect sizes were computed separately for pressure and electrical stimulations, and separately for young and elderly subjects. The values of these effect sizes are also listed in Table 1. For further analysis, only those AUs that reached an effect size of =0.5 (medium effect) in both age groups (these AUs are shaded in gray in Table 1) were used to form composite scores of pain-relevant facial responses.

3a. Prior to forming composite scores, the frequency values of all AUs had to be given weights. This was necessary because the frequency of AU 45 (blinking of the eye) is disproportionately higher than those of the other AUs. In order to reduce this numerical distortion, we decided to compute weighted frequency values for all AUs. This was performed by dividing the frequency of each AU at each stimulus intensity by the mean frequency of the given AU across all stimulus intensities.

3b. Composite scores of pain-relevant facial responses were formed by calculating the mean scores of those AUs that proved to be pain relevant (shaded in gray in Table 1) separately for each stimulus intensity, and separately for FACS frequency and FACS intensity.

3c. We also computed composite scores of pain-irrelevant AUs by calculating the mean scores of all AUs that did not prove to be pain relevant. This was performed to allow for the comparison between pain-relevant AUs and pain-irrelevant AUs and thus to evaluate the pain specificity of facial responses.

Self-report

Approximately 5–10 s after each stimulus application, subjects were asked to give self-report ratings regarding the peak sensation felt. The delay of 5–10 s was introduced to

[3] Pressure pain: All trials with stimuli rated as "mild pain" or more on the verbal scale were considered to be pain segments. Trials with stimuli rated as "no pain" were considered to be nonpainful segments. Similarly, all trials with stimuli rated above the R-III reflex threshold were classified as noxious segments, whereas all trials with stimuli rated below the R-III reflex threshold were classified as nonnoxious segments.

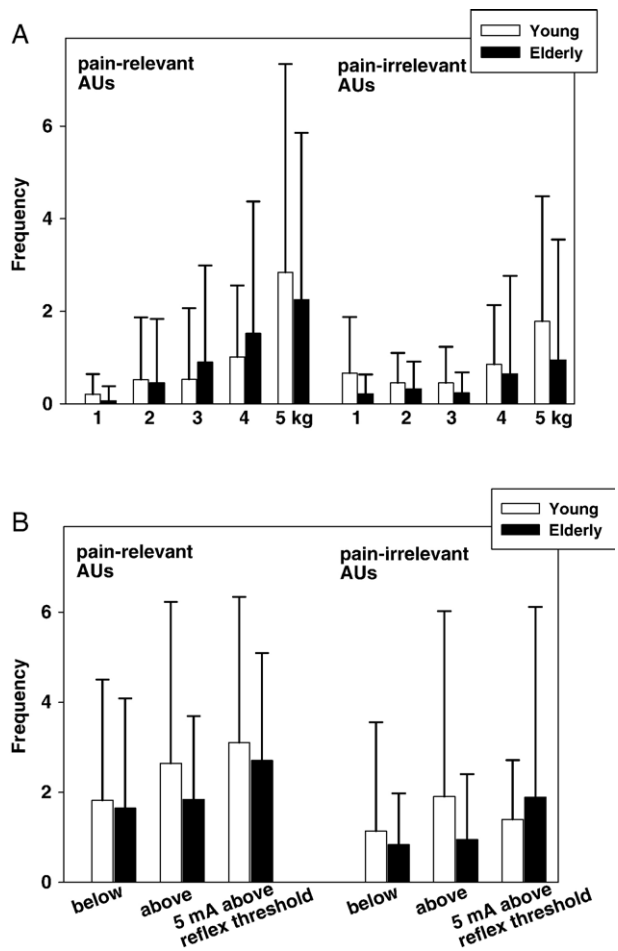

Fig. 1. Composite scores (in mean±S.D.) of the frequency of facial responses (pain-relevant and pain-irrelevant responses) during pressure stimulation (A) and electrical stimulation (B) (for explanation, see text).

guarantee an undisturbed facial response during the time segment of relevance. Self-report was assessed via a 6-point verbal category scale (*no pain*, *mild pain*, *moderate pain*, *strong pain*, *very strong pain*, *extremely strong pain*).

Statistical analysis

Age differences in facial responses to pain

To evaluate age differences in facial responses to pain (expressivity and specificity), we performed analyses of variance with repeated measurements with two within-subject factors Stimulus Intensity (pressure: 1–5 kg; current: below, above, and 5 mA above the reflex threshold, respectively) and Type of Facial Response (composite score of pain-relevant AUs and composite score of pain-irrelevant AUs), as well as one between-subjects factor Age Group (young and elderly subjects). Analyses were computed separately for the frequency and the intensity of facial responses. For a more detailed analysis, analyses of variance were performed separately for composite scores of pain-relevant facial responses and for composite scores of pain-irrelevant facial responses with one within-subject factor (Stimulus Intensity) and one between-subjects factor (Age Group).

Age differences in self-reports

To evaluate age differences in self-report ratings, we performed analyses of variance with repeated measurements with one within-subject factor Stimulus Intensity (pressure: 1–5 kg; current: below, above, and 5 mA above the reflex threshold, respectively) and one between-subjects factor Age Group (young and elderly subjects).

Findings were always considered to be statistically significant at $\alpha<.05$.

Results

Age differences in facial responses to pain

Age did not have a significant main effect on the frequency of facial responses to pain. Neither during pressure stimulation [$F(1,99)=0.498$, $P=.482$] nor during electrical stimulation [$F(1,90)=0.730$, $P=.395$] did young and elderly subjects differ in the frequency of their facial responses (see Fig. 1A and B). Furthermore, there were also no significant interaction effects with the factor Age Group [with the factor Type of Facial Response—pressure: $F(1,99)=2.238$, $P=.138$; current: $F(1,90)=0.244$, $P=.623$); with the factor Stimulus Intensity—pressure: $F(4,396)=1.758$, $P=.136$; current: $F(2,180)=2.324$, $P=.101$].

However, we found a significant effect of stimulus intensity on the frequency of facial response to pressure stimulation [$F(4,396)=26.998$, $P<.001$] and electrical stimulation [$F(2,180)=7.501$, $P=.001$]. As can be seen in Fig. 1A and B, facial responses increased across stimulus intensities. Furthermore, a significant effect for the factor Type of Facial Response was found for both pressure stimulation [$F(1,99)=8.533$, $P=.004$] and electrical stimulation [$F(1,90)=6.637$, $P=.012$], indicating higher composite scores of pain-relevant AUs compared to composite scores of pain-irrelevant AUs (see Fig. 1). Moreover, there was a significant interaction between Stimulus Intensity and Type of Facial Response for pressure stimulation [$F(4,369)=8.187$, $P<.001$]. As can be seen in Fig. 1A, the increase in pain-relevant AUs across stimulus intensities was steeper compared to the increase in pain-irrelevant AUs. `This interaction effect was not significant for electrical stimulation [$F(2,180)=0.311$, $P=.822$]; however, further analyses revealed that only the composite scores of pain-relevant AUs increased significantly across intensities [$F(2,180)=16.435$, $P<.001$], whereas the composite scores of pain-irrelevant AUs to electrical stimulation did not increase significantly [$F(2,180)=1.560$, $P=.213$]. All results of detailed analyses separating pain-relevant and pain-irrelevant AUs (for pressure and electrical stimulations) are displayed in Table 2.

Regarding the intensity of facial responses to pressure and electrical stimulations, statistical results did not differ from

Table 2
Results of analyses of variance for the effects of Age Group and Stimulus Intensity on composite scores of pain-relevant AUs and pain-irrelevant AUs during pressure and electrical stimulations

		Factors	*F*	*df*	*P*
Pressure stimulation	Pain-relevant AUs	Age Group	0.002	1,99	.963
		Stimulus Intensity	25.848	4,396	**<.001**
		Age Group×Stimulus Intensity	1.396	4,396	.235
	Pain-irrelevant AUs	Age Group	3.810	1,99	.054
		Stimulus Intensity	10.178	4,396	**<.001**
		Age Group×Stimulus Intensity	1.244	4,396	.292
Electrical stimulation	Pain-relevant AUs	Age Group	0.794	1,90	.375
		Stimulus Intensity	16.435	2,180	**<.001**
		Age Group×Stimulus Intensity	1.209	2,180	.301
	Pain-irrelevant AUs	Age Group	0.076	1,90	.783
		Stimulus Intensity	1.560	2,180	.213
		Age Group×Stimulus Intensity	1.859	2,180	.159

Significant results are marked in boldface.

the results obtained on the frequency of facial responses, in so far as the factor Age Group and any interaction including this factor did not have any significant effects on the intensity of facial responses during pressure and electrical stimulations. Therefore, we declined from reporting the results at this point in order to avoid doubling of findings.

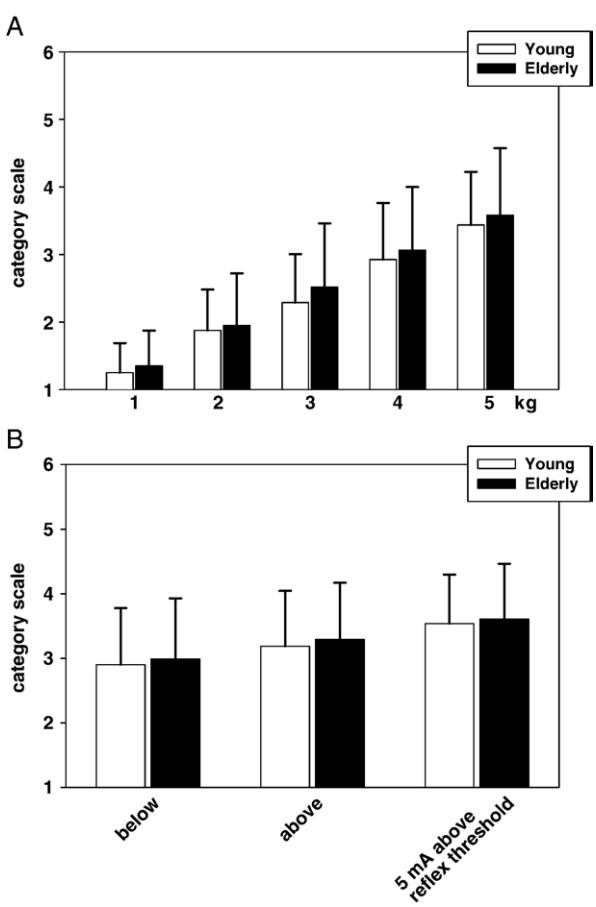

Fig. 2. Self-report ratings (in mean±S.D.) of pressure stimuli (A) and electrical stimuli (B).

Age differences in self-reports

Age had no significant effects on self-report ratings of pressure stimulation [$F(1,99)=0.962$, $P=.329$] or electrical stimulation [$F(1,89)=0.273$, $P=.603$]. As can be seen in Fig. 2A and B, young and elderly subjects did not differ in the ratings of the stimuli. There was also no significant interaction between the factors Age Group and Stimulus Intensity [pressure stimulation: $F(4,396)=0.451$, $P=.772$; electrical stimulation: $F(2,178)=0.049$, $P=.952$]. This indicates that the increase in pain intensity ratings across stimulus intensities did not differ between young and elderly subjects. However, we found a significant effect of stimulus intensity on pain ratings both for pressure stimulation [$F(4,396)=406.550$, $P<.001$] and for electrical stimulation [$F(2,178)=57.525$, $P<.001$)], with higher stimulus intensities leading to higher pain ratings.

Discussion

There were two major findings as regards facial responses during noxious stimulation. (i) The frequencies of facial responses (defined as a cluster of muscle movements evoked by the experimental pain stimuli of our study) did not differ between young and elderly subjects. Therefore, facial expressivity during pain appeared unaltered by age. (ii) The facial responses were specifically conveyed by this cluster of muscle movements and not by other facial actions both in young and in elderly subjects. Therefore, the specificity of facial responses during pain also appeared to be unaltered by age. We will discuss these findings in this order.

Age effects on the facial expression of pain

To our knowledge, this is the first time that the influence of age on the facial expression of pain has been systematically investigated. So far, research on age-related changes in facial expression has only concentrated on facial

expressions of other affective states. The majority of findings from this research suggest that the facial expressivity of emotions does not change with older age [7–10]. In accordance with these previous studies, we found that age also has no significant effect on the facial expressivity of pain. Elderly and younger subjects did not differ with respect to the frequency of facial responses to pressure and electrical stimulations. Moreover, the increase in the frequency of facial responses across stimulus intensities did not differ between age groups, thus indicating that age does not seem to affect the slope of the facial expressivity of pain across stimulus intensities.

Besides investigating age-related changes in the facial expressivity of pain, we additionally looked at the impact of age on the specificity of facial responses to noxious stimulation. Our findings suggest that the specificity of facial responses to noxious stimulation is also not affected by age because the distribution of pain-relevant and pain-irrelevant AUs elicited by pressure and electrical stimulations did not differ significantly between young and elderly subjects. Therefore, we conclude that elderly individuals communicate pain through their facial expression as specifically as younger individuals do, thus yielding clear support for the use of the facial expression of pain as a valid pain indicator in older persons, as has been previously suggested by other authors [28].

In summary, our findings add to the empirical evidence on age-related changes in facial expression by showing that the facial expression of pain (like facial expressions of other affective states) seems to be unchanged by age. Thus, once more, the traditional view of an age-related decline in emotion-expressive behavior has been contradicted.

Interestingly, however, when considering self-evaluation measures of the behavioral expressivity of pain, elderly subjects have been found to rate themselves as being more stoic when "displaying" pain to others, compared to younger subjects [16,29,30]. Therefore, there seems to be a discrepancy between self-evaluation of expressivity (as found by Yong et al. [16,30] and Yong [29]) and the actual behavioral expressivity (as found in the present study), which has also been observed in research on age-related changes in the behavioral expressivity of other affective states (as described in the Introduction).

What might be the reason for these discrepancies? One possible explanation is that the traditional stereotype of an age-related decline in emotional expressivity [1,2] is common and influential, contributing to the self-perception of emotion-expressive behavior in elderly individuals. However, this explanation is only speculative, and further research that aims to assess self-perceived and true facial responses in parallel is needed to clarify discrepant findings.

Age effects on self-reports of pain

Young and elderly subjects did not differ in their ratings of the pressure and electrical stimuli applied, thus indicating that both age groups experienced comparable amounts of pain intensities. Regarding the ratings of the pressure stimuli, our findings are somewhat surprising because previous research has pointed to increased sensitivity to pressure pain in elderly individuals [31–34]. Therefore, we expected higher pain ratings in elderly subjects. So far, age differences in pressure pain sensitivity had been mainly reported for pain threshold and tolerance values (e.g., Lautenbacher et al. [32] and Woodrow et al. [34]). Therefore, it is possible that age-related differences in pressure pain sensitivity are more or less likely to be found depending on the psychophysical method used. Besides sensory input, psychophysical data are affected by response tendencies, which are picked up in a differential manner by various psychophysical parameters and may differ between age groups. Since previous research has found no evidence of age-related changes in pain sensitivity to electrical stimulation (for a comprehensive review, see Gibson and Farrell [12] and Gibson and Helme [13]), the lack of age differences in self-report ratings of electrical stimuli was expected. The lack of age changes in our self-report measures for pressure and electrical pain does not mandatorily exclude age changes in facial responses. Subjective and mimic responses to noxious stimulation are independent indicators of pain, as demonstrated by a generally weak correlation between the two response systems [25,35].

Limitations

As described in Materials and Methods, subjects underwent an extensive neuropsychological and neurological examination before they were included in the study. This might have resulted in a sample of "superhealthy" elderly subjects, which may have possibly limited the degree to which our results can be generalized. However, it would have been an even greater shortcoming if we had been less strict with respect to the inclusion criteria. Since older age is associated with an increase in pathological conditions that can affect pain processing and pain experience (e.g., chronic pain and neuropathy), less strict inclusion criteria would have crucially reduced the internal validity of our findings.

Furthermore, the sex distribution in the groups of young and elderly subjects was not balanced; thus, it is possible that our findings in relation to age might have been confounded by sex. To exclude this possibility, we looked at the interaction between the factors Age and Sex in an additional analysis of variance. Neither for facial nor for subjective responses did we find significant interactions between the two factors.

Conclusion

In conclusion, our findings extended previous findings on age-related changes in emotion-expressive behavior by suggesting that the facial expression of pain—like facial

expressions of other affective states—is not changed in older persons. Consequently, elderly individuals appear to communicate pain through their facial responses as validly as younger individuals do.

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