Special Issue Article

Reduction of head and face pain by challenging lateralization and basic emotions: a proposal for future assessment and rehabilitation strategies

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Chronic facial pain has many of the clinical characteristics found in other persistent musculoskeletal conditions, such as low back and cervical pain syndromes. Unique to this condition, however, is that painful facial movements may result in rigidity or altered ability to demonstrate mimicry, defined as the natural tendency to adopt the behavioral expressions of other persons involved in the interaction. Loss of ability to communicate through emotional expression can lead to impaired processing of emotions and ultimately social isolation. Diminished quality and quantity of facial expression is associated with chronic face pain, tempromandibular dysfunction, facial asymmetries, and neurological disorders. This report provides a framework for assessment of impaired emotional processing and associated somatosensory alterations. Principles for management for chronic facial pain should include graded motor imagery, in addition to standard treatments of manual therapy, exercise, and patient education. A case study is provided which illustrates these principles.

Keywords: Head and facial pain, Lateralization, Emotion recognition and expression, Graded Motor Imagery, Rehabilitation

Introduction

Studies have demonstrated that the presentation of chronic pain conditions such as low back pain,[1–3] as well as headache and orofacial pain,[4–7] has common characteristics. Pain localization in these conditions often exhibits spreading pain into other areas. Additionally, multistructural somatosensory changes and changes in the affective and cognitive status may occur.

In the 'International Classification of Headache Disorders 2nd Edition' (ICHD-II),[8] the International Headache Society classifies head and orofacial pain mainly by diagnoses. However, these definitions are too vague,[9,10] particularly for chronic idiopathic face pain, in which the diagnosed cause often does not match the magnitude of the problematic pain. This is reflected in a complex array of clinical symptoms. A large number of patients with chronic orofacial pain cannot be classified, making it difficult to study this group of patients over an extended period of time.[11]

Patients with facial pain often experience physical and psychological changes. Facial expression may change, such as increased rigidity or altered ability to demonstrate mimicry, which is defined as a person's natural tendency to adopt the behavioral expressions of interaction partners.[12] As a consequence, individuals with chronic facial pain may begin to lose contact with people and become more socially isolated.[13,14] Therefore, management of this condition, which is likely more prevalent than is presently reported, should be multimodal. Specifically, the range of therapy should be as varied as possible in order to consider all factors. It is known, for example, that a person's own pain management of headaches is closely connected with the degree of severity of the disease,[13,15] meaning that patients who can control their pain and feel comfortable with their medical specialists may manage their illness better than patients who catastrophize about their condition and therefore, focus too much on the pain.[15] In fact, despite multimodal therapeutic interventions, the incidence of chronic atypical face pain is increasing.[16] Zakrzewska[17] reported that nearly 7% of the population can suffer from face pain, while Madland and Feinmann[18] estimated that nearly 10% of the adult population experiences orofacial pain.

The face has the unique physical ability to communicate in a non-verbal manner. The multitude

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Figure 1 The six basic emotions: happiness, sadness, surprise, anger, disgust, and fear.

of emotional expressions and the recognition of expressions in other faces affects, in large part, the quality of our lives.[12–14,20] Recent studies have examined how quality of facial expressions and facial recognition may contribute to the transition to chronic head and face pain.

Recognition of Emotion and Expression

In addition to orofacial functions such as chewing, yawning, speaking, and singing, the human face is fundamentally important for interpersonal communication. Facial expressions are initially illustrated and processed horizontally, i.e. through the upper half of the face and only in a secondary process, are they illustrated and processed over the right and left half of the face.[21,22] The literature clearly differentiates between primary and secondary emotions.[22] Primary emotions are our basic innate emotions acquired by an evolutionary process and they include fear, anger, surprise, happiness, sadness, and disgust. These facial expressions of emotions are explicitly coded from birth and they have the same meaning for humans of any ages[12] (Fig. 1). They are defined by spontaneous expressions and serve mainly as protective and escape mechanisms.[19,22] Current research has demonstrated that primary emotions are controlled by the right brain hemisphere and that they are expressively conveyed through the upper region of the face (eyes/forehead).[21,22] Secondary emotions are based on social standards and these are acquired during infancy. They differ from culture to culture and are strongly context-dependent. Facial blends are typical for such secondary emotions. They are created by an inhibition or suppression of spontaneously triggered basic emotions. The social, emotional system is mainly controlled by the left brain hemisphere and it is expressed in the lower part of the face.[21,22]

The ability to recognize faces and facial expressions and participate directly, is required for a perfect

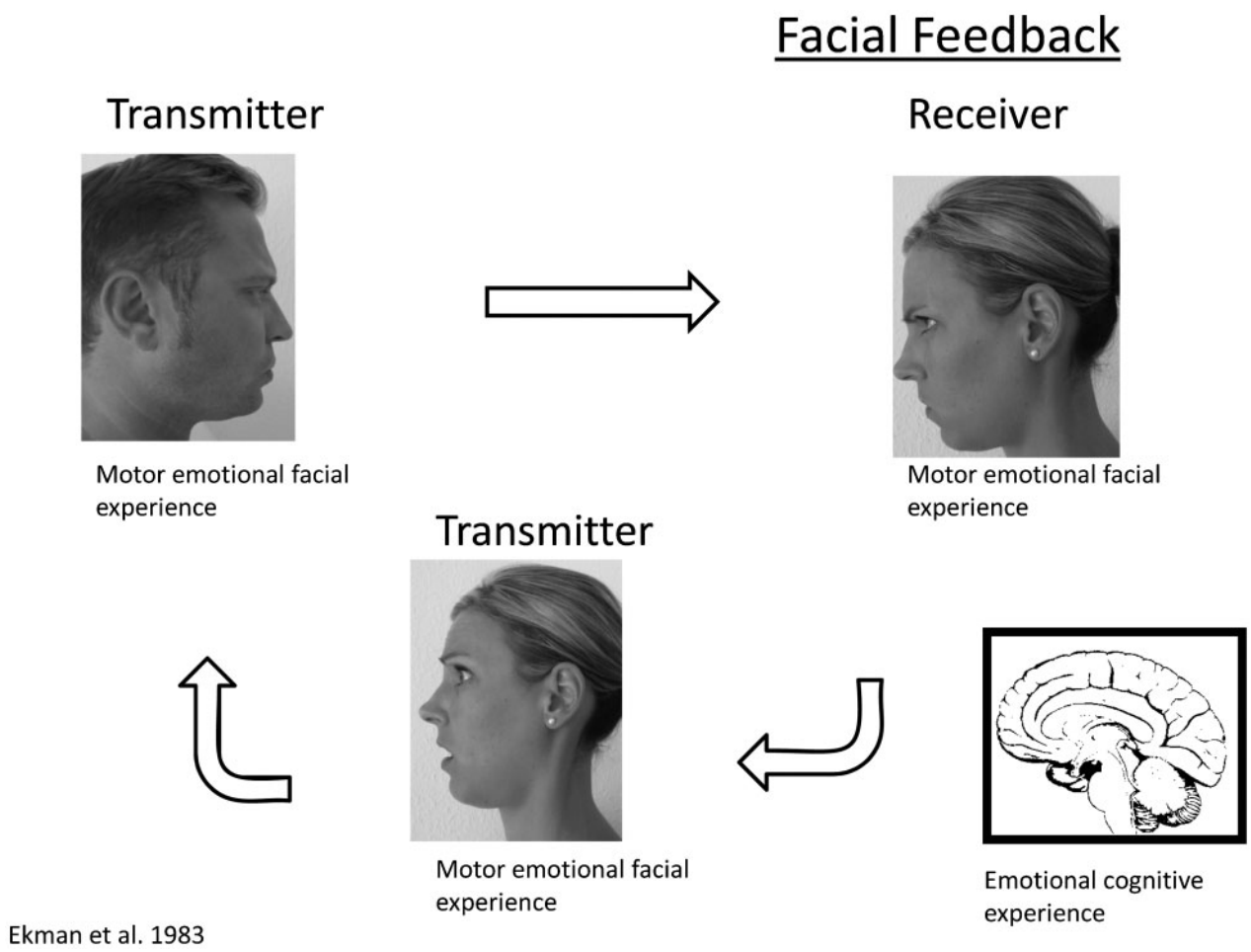

Figure 2 Facial reflex modified according to Ekman *et al.*[26]

intercommunicative relationship.[23] Research studies have shown that diminished quality and quantity of facial expression is associated with chronic face pain, temporomandibular dysfunction, facial asymmetries, and neurological disorders, such as facial paresis and Parkinson's disease; however, it can also be influenced by affective dysfunctions such as depression.[13,24,25]

To understand one's own feelings and display them is closely connected with the ability to recognize and interpret them through mimicry and gestures to other human beings.[23,26] When a person recognizes an emotion in another's face, it stimulates a response to mimic the facial expression with their own facial muscles; this has been called the facial reflex. (Fig. 2).[27] This reflex activates cortical areas, which are directly connected with our recognition of emotions. According to Neal and Chartand,[28] women injected with Botox have difficulties for mimicking facial expressions because of their own reduced muscle activity and therefore, they have difficulty recognizing the emotions of other persons. The ability to reflect the emotions of other people is a necessary prerequisite for being able to recognize and express our own feeling. Hence, we can influence our emotional state by a voluntary or intentional change of the facial expression.[29]

Even minute changes of this code can result in misinterpreting the non-verbal messages in the faces of others.[12] This can be decisive for human interaction. It can be a large problem for patients, whose recognition of emotions is impaired. It negatively affects the loop of the facial feedback theory, which in turn can lead to communicative insecurities and, consequently, interferences in the social environment of the patients.[30] Impeccable and symmetric mimicry is often categorized as attractive, which in turn characterizes the image and therefore the social standing of the person.[31] The frequency and quality of personal relationships are decisive factors of our wellbeing and the quality of life.[15]

Symmetry and Asymmetry in Facial Expressions

The research literature differentiates between symmetrical and asymmetrical While positive emotions are mostly displayed symmetrically, negative emotions are defined by an asymmetric facial expression (Table 1), requiring a specific motor control of the facial muscles. This fact requires a specifically working motor control of the facial muscles. However, in chronic temporomandibular disorder and face pain, the cortical representation of the right and left side of the head and face ('disrupted body schema') can be

Table 1 Characteristics of basic emotion with regard to (a)symmetry

Basic emotions	Emotional state	Motor activity
Happiness	Positive	Symmetrical
Surprise	Neutral	Symmetrical
Fear	Negative	Asymmetrical
Anger	Negative	Asymmetrical
Disgust	Negative	Asymmetrical
Sadness	Negative	(a)symmetrical

impaired.[32,33] As a result, difficulty in controlling facial muscles in a defined proper manner can create a deficit in the representation of basic asymmetric emotions.

According to Ekman,[34] pain is not a basic emotion. He suggests that facial expression of pain is composed reactively by the other basic negative emotions. Despite this, a specific pattern of unchanging but mostly asymmetric mimic characteristics have been defined as a pain pattern in the literature.[32,35] Based on the emotion of pain, the link between sensory recognition and the recognition of emotions is most evident. Sensory stimuli arrive through the thalamus and are initially processed in the limbic system (corpus amygdaloideum) and only then transmitted to the hypothalamus. Whether a stimulus is beneficial or negative is decided in the amygdala (escape-fear response). Therefore, processing pain and recognizing emotions are neurophysiologically linked.[36]

Potential Changes during Chronic Headache and Facial Pain

Through impaired facial muscle activation, chronic facial pain can affect mimicry, which takes an important role in social interaction and as means of communication.[12,30,31,37] This is triggered by pain behavior in chronic facial pain such as changed mimicry[32] or a pain-relieving posture of the affected region.[13] The loss of the basic ability to recognize mimicry-coded basic emotions can lead to misunderstandings, limited empathy, and insecure social behavior.[24,27]

In this context, a progressive impairment of the ability to recognize emotion in facial expressions can lead to psychological symptoms such as alexithymia.[38] Alexithymia is the inability of a person to recognize and express feelings.[38] Patients with characteristics of alexithymia show significantly less activity in the emotion-processing centers of the brain.[36] Current research results suggest that the recognition of mimicry-coded emotions and the presence of alexithymia are closely related.[24,36,39] Therefore, patients with characteristics of alexithymia often show signs of fear and depression.[39]

Other studies have reported on altered mimicry in patients with facial pain. For example LeResche *et al.*[39] investigated the changed facial expression during the emotion of pain in individuals presenting with chronic temporomandibular disorder dysfunction.[32,39] Therefore, it is known that patients with orofacial pain show basic emotions asymmetrically whereby this can be recognized best in the emotion of pain.[32,39] These results are supported by a study conducted by von Piekartz *et al.* (in preparation).

Change in the cortical matrix

The recognition of laterality is of great significance for a functioning body schema. Laterality recognition (or right/left recognition) is defined as the ability to assess the right and left side of the illustrated body part.[40] Several clinical studies have described deficits in laterality recognition in the following pain symptoms: chronic hand pain, chronic low back pain, neck pain, chronic tension headache, or foot/leg pain after amputations.[2,5,7,41,42] Based on this evidence, it can be assumed that the neural networks in the premotor cortex, which are necessary for a physiological body schema and for a good function of a body part, are altered.[2] It is conceivable that neurons of the sensomotoric homunculus representing the part of the face will be sensitized and uninhibited by facial pain. This means that neurons have a higher excitability and are uninhibited even the surrounding neurotags.[22] The clinical consequences are new pain and a changed recognition of the shape and size of the area representing the face, so-called smudging[2] (Fig. 3) — as was investigated with regard to other body regions.[2,7] For example, these patients can recognize the affected side as larger or only blurred. In the facial region, this could result in a distortion or rigidity of one's own mimicry.[13] As a consequence, it can affect the motor expression of the facial expression and later, the ability to recognize emotions.

In addition to dysfunctional cortical representation, these patients with chronic pain often show a changed tactile recognition in the pain region.[42,43] This observation becomes measurable with two-point discrimination. Two-point discrimination is defined as the ability to recognize two tactile stimuli of the skin separately from one another.[44] According to Haggard *et al.*,[44] tactile discrimination of various body sections correlates with the representation at a primary sensory cortex.

In addition, this theory supports a study of von Piekartz *et al.* (unpublished data). In this study, patients with chronic facial pain took part in two testing procedures, which objectively measured laterality recognition and recognition of facial expressions independently. In both tests, the results of the patients with chronic facial pain were significantly worse than those from the healthy group. This relationship

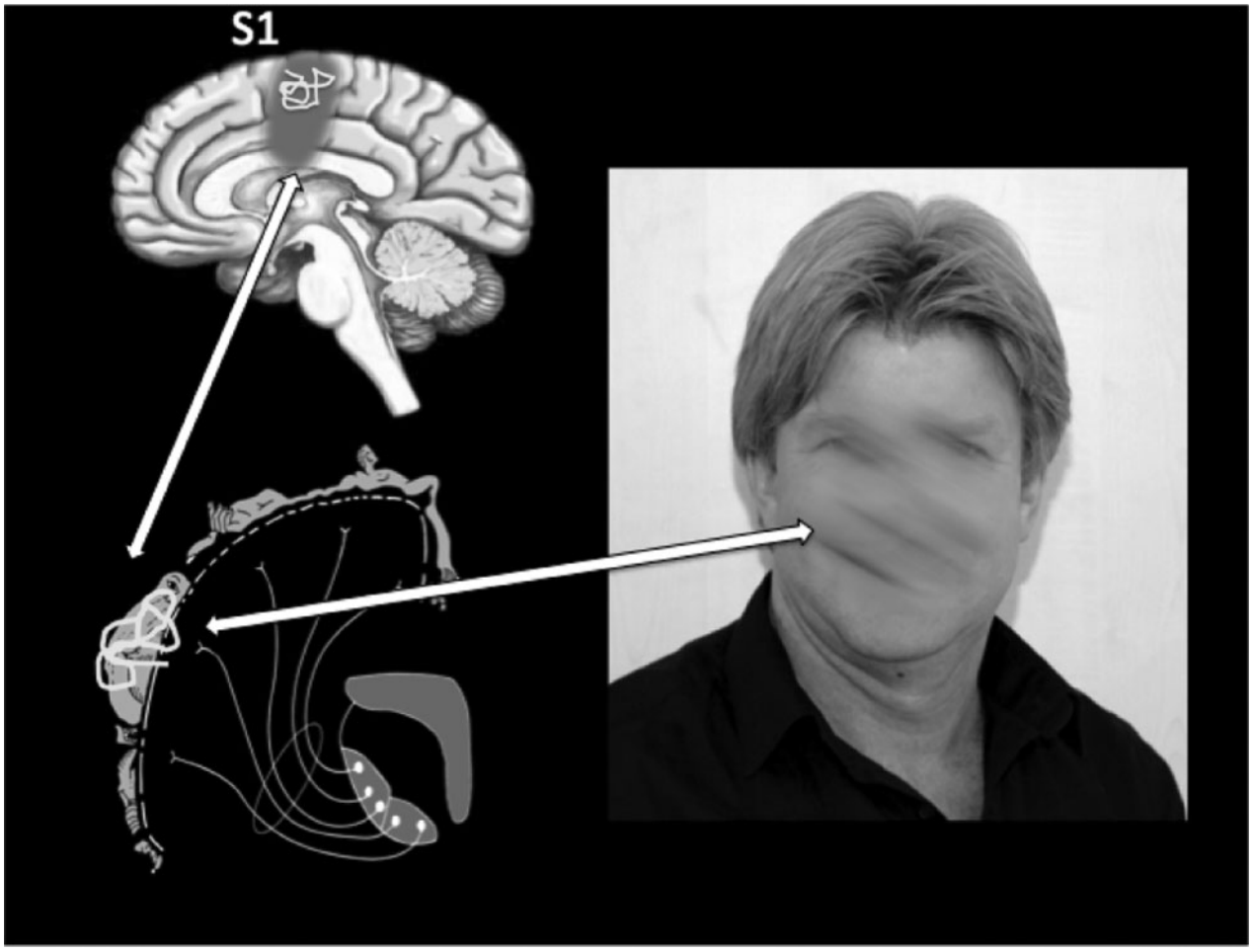

Figure 3 Change in the cortical representation of the facial region 'smudging' (S1=sensory cortex).

supports the hypothesis that with increasing pain chronicity, the cortical representation of the affected body region — in this case the face — is affected first. This can have a secondary negative effect on the recognition of emotional facial expressions.

Based on this theoretical background, it can be concluded that patients with chronic head and facial pain may first show deficits in the ability to recognize the right and left side of the face. This limitation causes dysfunctional two-point discrimination and a reduced ability to express emotions and recognize them and to recognize them in the faces of others. The social issues connected therewith have already been explained. Without focused training of the body schema, the neuromatrix may show pathological changes in the long term, which can cause a significant limitation in the affected person's ability to communicate non-verbally. Therefore, in addition to a standardized neuro-musculoskeletal assessment and treatment of the craniomandibular, facial, and cervical regions, an assessment of the quality of the facial laterality and the recognition of emotions is also suggested. This will be described in the following paragraphs.

Clinical Tests to Measure Laterality and Emotion Recognition

CRAFTA Face Mirroring Program

The face mirroring test developed in 2012 utilizes the principle of mirror therapy. The program assesses motor control of the facial muscles and at the same time, serves as a basis for treatment. During the treatment of extremities, the affected part of the body is covered by a mirror. If a computer program is used, this is done digitally through an image setting (Fig. 4). During this procedure, the patient sits in a comfortable position in front of a laptop with integrated webcam. The therapist specifies the settings, so that the affected facial side is covered and the healthy side of the face is reflected as a mirror image so that it creates the illusion of two healthy sides of the face. The patient sees his face on the display and can correct his or her motor action actively. The therapist can offer verbal and tactile support. The program can be configured in many ways. The patient's face can be reflected in full or only in part (lower part/upper part, right and left halves, and so on). The therapist can set restrictions, while the patient attempts to correct his or her

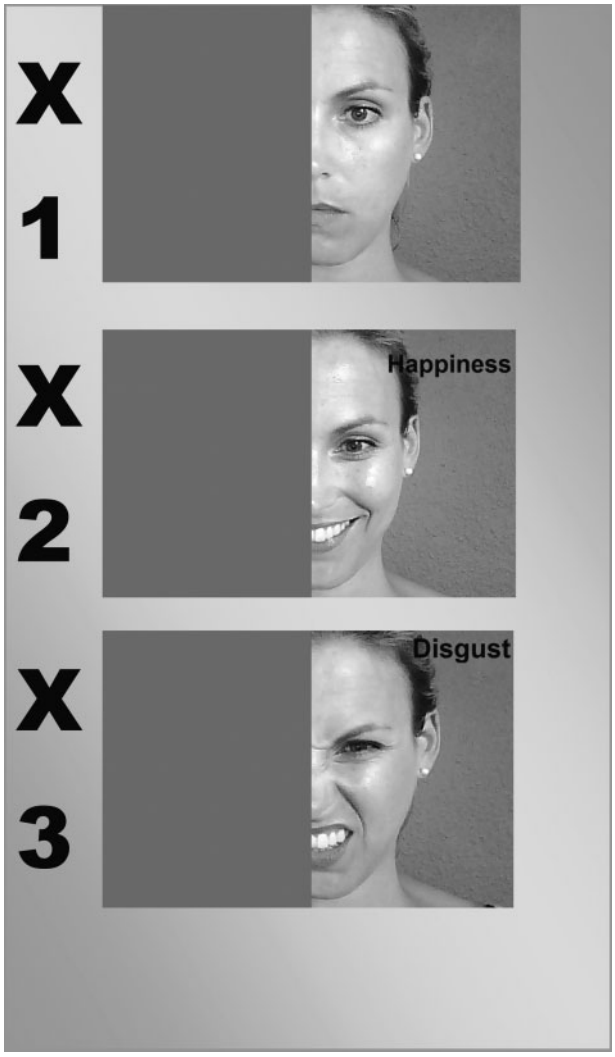

Figure 4 Training of emotional facial expression with the Mirroring Program (Crafta 2013). The patient starts in neutral (X1), then initiates the training with the defined and described facial expressions of basic emotions (X2–X3). This can be carried out with the same side or mirrored (healthy side is activated, but the patient sees the healthy side as the affected side).

movements. The program is very easy to use, making it ideal for patients with access to a laptop to perform at home as part of their self-management.

CRAFTA Lateralization Left/Right Test

The computer-guided CRAFTA Lateralization developed in 2013 (Fig. 5) test measures recognition of motor activity on the left and right sides of the body as well as recognition of emotions. It measures accuracy (in percent) and speed (in seconds) of laterality and emotion recognition. In 2012, Neuro Orthopaedic Institute[46] of Australia developed the test in cooperation with CRAFTA. It has both clinical and therapeutic utility.

The face program consists of a slide show of colorful images of faces. Each image shows a different picture of the right or left side of the face (Fig. 5) or one of the six basic emotions (Fig. 6), and participants are asked to respond to the images. In the laterality test, participants are asked to identify the model's eye, tongue, eyebrow, or jaw as moving on or towards either the left or right side of their face. During the emotion test, participants are asked to report which of the six expressions they believe the model is displaying: happiness, sadness, disgust, anger, fear, or surprise. Participants are instructed to use the computer mouse to input their response. The images are rotated by 90° toward the left or right, or by 180°. Figure 5 shows an example of an image of a face.

Currently, a pilot study with a representative sample size to test reference values of facial recognition is at the planning stage. Beames[47] has shown that the accuracy rate of a normal response for left–right recognition of the upper extremity is $\geq 80\%$, and that it takes an average of 1.9 seconds. These values should be about identical for recognition of both sides of the body.[2]

Two-point discrimination

It is known that chronic pain correlates with changes in tactile perception.[42,47–49] This is clinically seen by an increase in the two-point discrimination threshold in the affected region.[50] In addition, correlations between tactile discrimination and cortical representation on the somatosensory cortex have been identified,[43] showing changes in representation in the sensory homunculus in persistent pain. As described earlier, new pain and an altered recognition of the shape and size of the area may result (Fig. 3).

The investigation of static two-point discrimination (the ability to distinguish two tactile stimuli of the skin separately one from another)[43] is a functional examination and progression assessment in the treatment of face pain and headache. It was described by Weber[45] in 1834, and Vriens and van der Glas[52] who modeled their procedure with standardized measuring points after this method. The standardized measuring points (Fig. 7) can be used to examine the trigeminal nerve with its three branches. For this examination, the patient lies comfortably in supine. The measuring instrument is placed on the skin so that the pressure slightly deforms the surface of the skin, and is applied for approximately 2 seconds. The patient then states whether he or she has felt one or two points.

Starting with a maximum distance of 25 mm, the distance between the two points is reduced to 20 mm, then 15 mm, and then by 1 mm each time. The patient evaluates each stimulus as either one or two points. To verify accuracy of the testing procedure, a single stimulus can be applied randomly during the measuring sequences. The results can be repeated regularly and used to assess the patient's progression.

Proposed treatments

With the exception of one case study, there is no published evidence of the efficacy of feedback

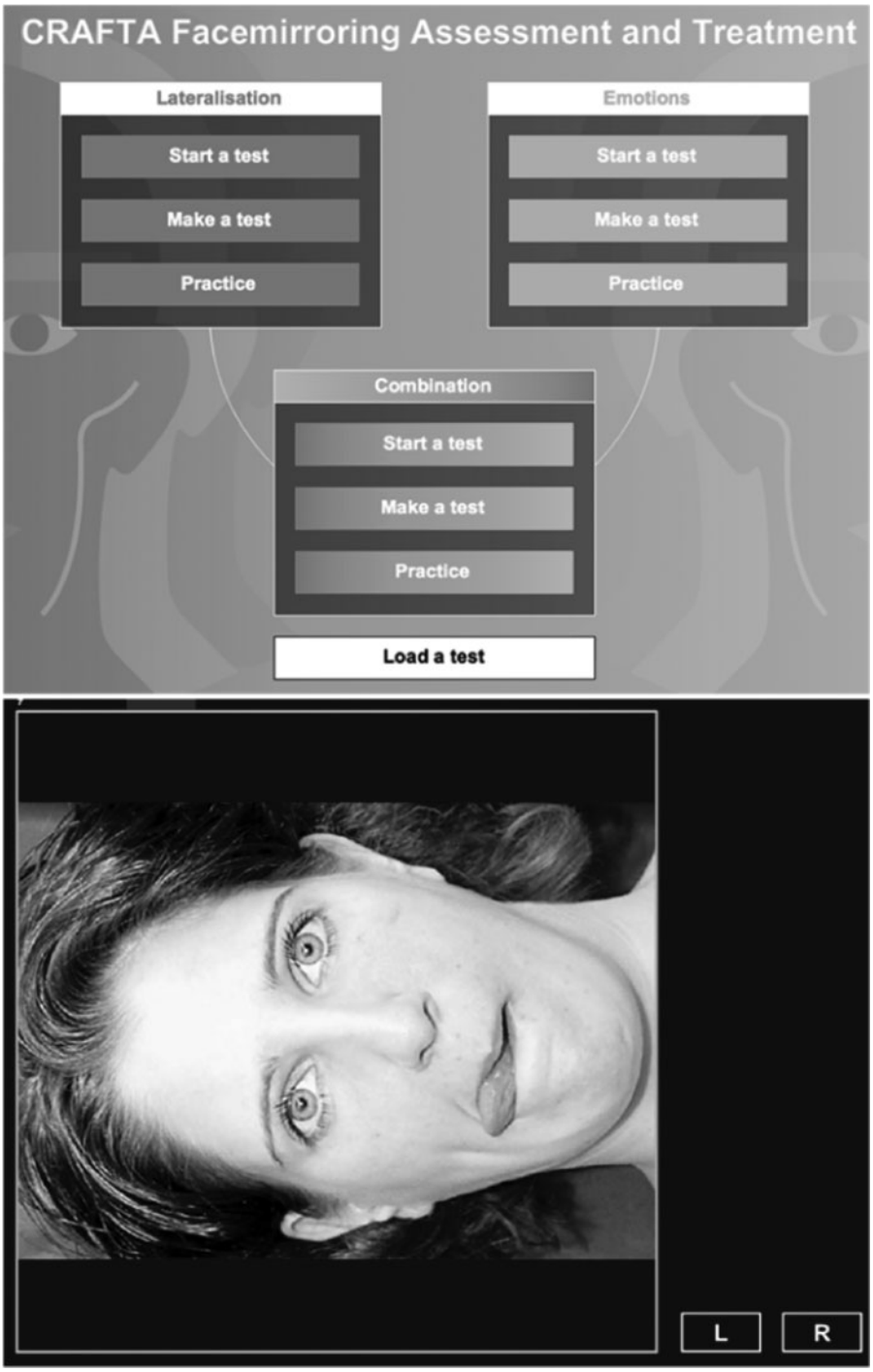

Figure 5 Menu and display of the right-left recognition of the CRAFTA Lateralization Test with examples.

training of left–right or up–down recognition and emotion recognition training in patients with neck, head, and facial pain. The current case study of two patients with persistent idiopathic face pain demonstrated that, with the help of a digital model (Avatar) on a regular PC, it was possible to reduce allodynia and pain in the face. The patients' face was mirrored and active physical exercises were carried out.[52] Studies on chronic pain involving the upper or lower extremities have indicated that applying therapies in the following order leads to an improvement in function and a decrease in pain: left–right discrimination, imagined motor function, and mirror therapy. This format is called graded motor imagery.[2] The authors contend, based on their clinical experience, that it is useful to start with the graded motor imagery program for the face and then continue with emotion training. It is assumed that the right–left recognition activity stimulates the prefrontal cortex in the brain, which can have a positive effect on the subsequent therapy.[2]

Some therapy options are discussed in the next section. It should be noted that these options are presented as complements to, not replacements for, other therapies, which may include manual techniques, behavioral therapy, and self-management education.[53]

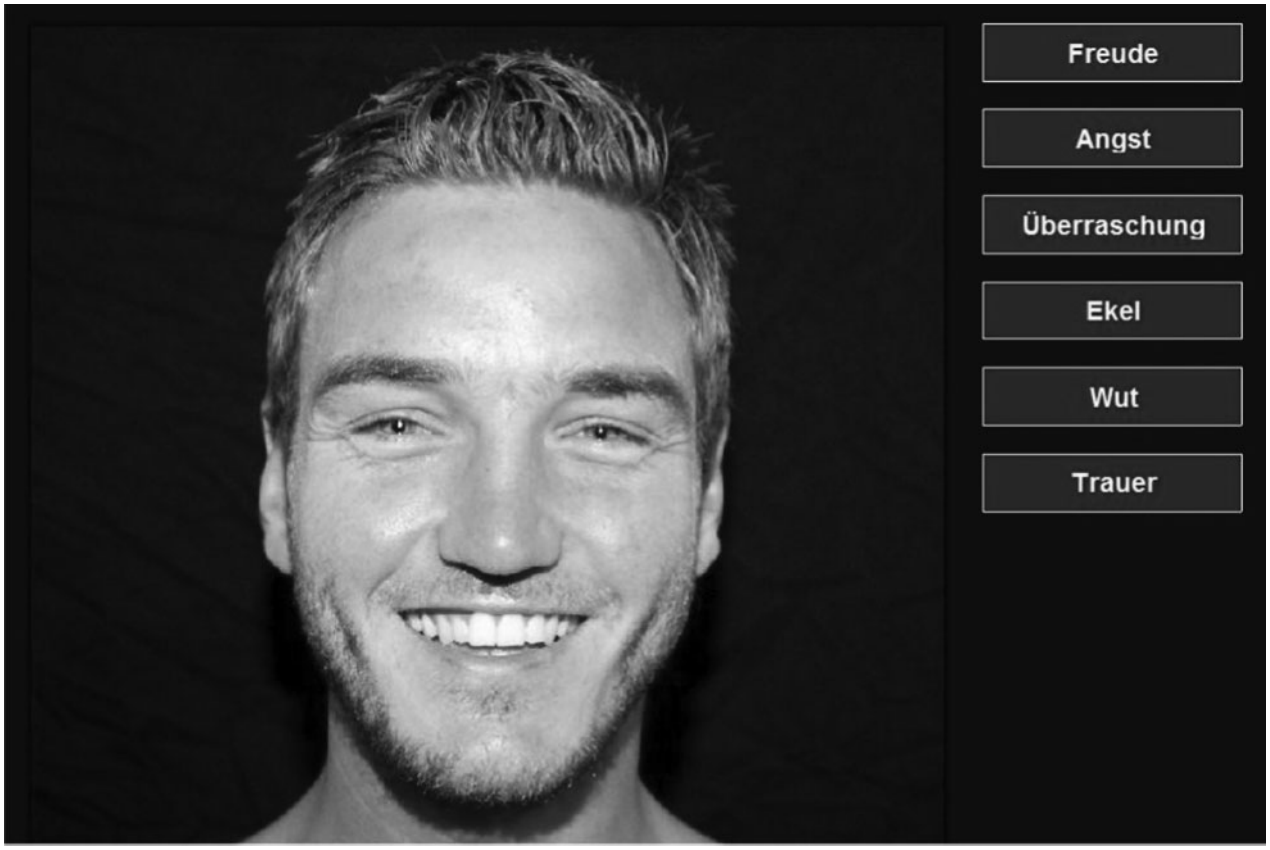

Figure 6 Display of the emotional task of the CRAFTA Emotions Test.

Figure 7 Two-point discrimination test.

Graded Motor Imagery

The 'Graded Motor Imagery' program, which was established at the Neuro Orthopaedic Institute,[46] consists of training in recognition of the direction of movement from the left to the right side, i.e. laterality (CRAFTA Lateralization Left/Right), and the motor imagery and the mirror therapy (CRAFTA face mirroring program). This order is recommended for maximum effectiveness,[2] and the same sequence should be carried out for facial disorders until new evidence indicates otherwise.

1. The *CRAFTA Lateralization Left/Right Test* can be used to assess and train left–right discrimination for speed and accuracy. The therapist or patient has the ability to configure the number of images and the duration of display of an image. The images show faces of persons performing an activity on the left or right side of the eyes, tongue, and nasolabial fold or of the jaw. The patient's task is to identify the side of the face on which the activity is occurring as swiftly as possible. With this training, the neuronal connections are reorganized in the brain and therefore symptoms are reduced.[2]
2. After the right–left discrimination test, the patient is asked to imagine himself performing a movement without actually executing it (motor imagery). In this context, the brain areas and motor neurons are stimulated more strongly than if the motion is solely observed.[54] For patients who experience pain during execution of a movement, imagining the motion decouples it from the pain experience. This specific preparation (explicit imagery) makes the motion subsequently easier and less painful.
3. With *mirror therapy*, the process of motor imagery is reinforced because the healthy part of the patient's body is used to display a second healthy part of the body; thus, the brain is visually deceived.[41] In motor function disorders of the upper or lower extremities, it is easy to use a mirror, in which the healthy extremity reflects a second healthy half of the body. In facial problems, it is more difficult to use a mirror. The CRAFTA Face Mirroring Program allows a mirror image of the healthy side of the face to be created using a camera on a laptop or tablet, while the affected half of the face is covered. This application has benefits in motor dysfunctions such as facial paresis or in problems with recognition of facial emotional expression.

Implementation into daily routine

The first goal is to educate the patient about the relationships between facial pain and headaches and the processing of emotions. This enables the patient to train his or her perception and to work actively on non-verbal communication. Easy exercises are available, which the patient can integrate into his or her daily routine.

EmoRec-Cards

CRAFTA EmoRec-Cards (Emotion-Recognise-Cards, Crafta 2011) can be used for training recognition of facial expressions of mimicry and for identification of the right and left side of the face. The square cards are printed on both sides. On the one side, there is a drawing depicting a facial expression of one of the six basic emotions. The people depicted on these cards differ by age and ethnicity. On the other side, a person is depicted according to the principle of the GMI program, moving either the right or the left side of the face.

The cards can be used to test and train the ability to recognize facial expression and emotions, and patients can work on reproducing the illustrated motions actively. EmoRec-Cards are characterized by their ease use and multitude of uses and they offer a cost-efficient alternative to computer programs. Therapy with EmoRec-Cards is particularly well suited for patients who cannot use digital media because of their age or cognitive limitations.

Magazines/books

Magazines are also suitable for assessment and training of laterality recognition.[2] Images of the problem area, e.g. hand or face, are selected for laterality recognition. The degree of difficulty can be increased by turning the magazine toward the right, left, or upside down. The patient is instructed to mark the laterality with a pen.

Case Study

Lisa is a 22-year-old woman with a 7-year history of persistent chronic right-sided facial pain. Brushing her teeth, normal talking, and drinking cold or warm water produced an ache in her right maxillary premolar tooth. For 4 years, Lisa has been taking Gabapentin three times daily with only partial relief of pain. Lisa reported that the pain would subside for a few days, but recurred spontaneously, usually triggered by fatigue or cold wind. She underwent MRI testing 4 years ago and was diagnosed by a neurosurgeon as having congenital dolichobasilaris on the right (pressure from the basilar arteries to the cranial nerves and in this case, on the trigeminal nerve). Typical treatment for this is medication or surgical suboccipital release if the pain increases. During physical examination of the cranio-cervical region, marked limitation of cervical flexion was noted (2–5°); all other movements were within normal limits. The only other significant finding was of severe allodynia on palpation of the suborbital maxillary nerve. Because of the unilateral presentation and chronic nature of Lisa's pain, the authors administered the CRAFTA Lateralization and emotion recognition test. Table 2 shows the results of the first treatment and of the sixth treatment. In the first treatment, laterality of the left half of the face was significantly worse than the right half of the face in terms of accuracy and response time. With regard to emotion recognition, happiness and anger were recognized much less often than the other basic

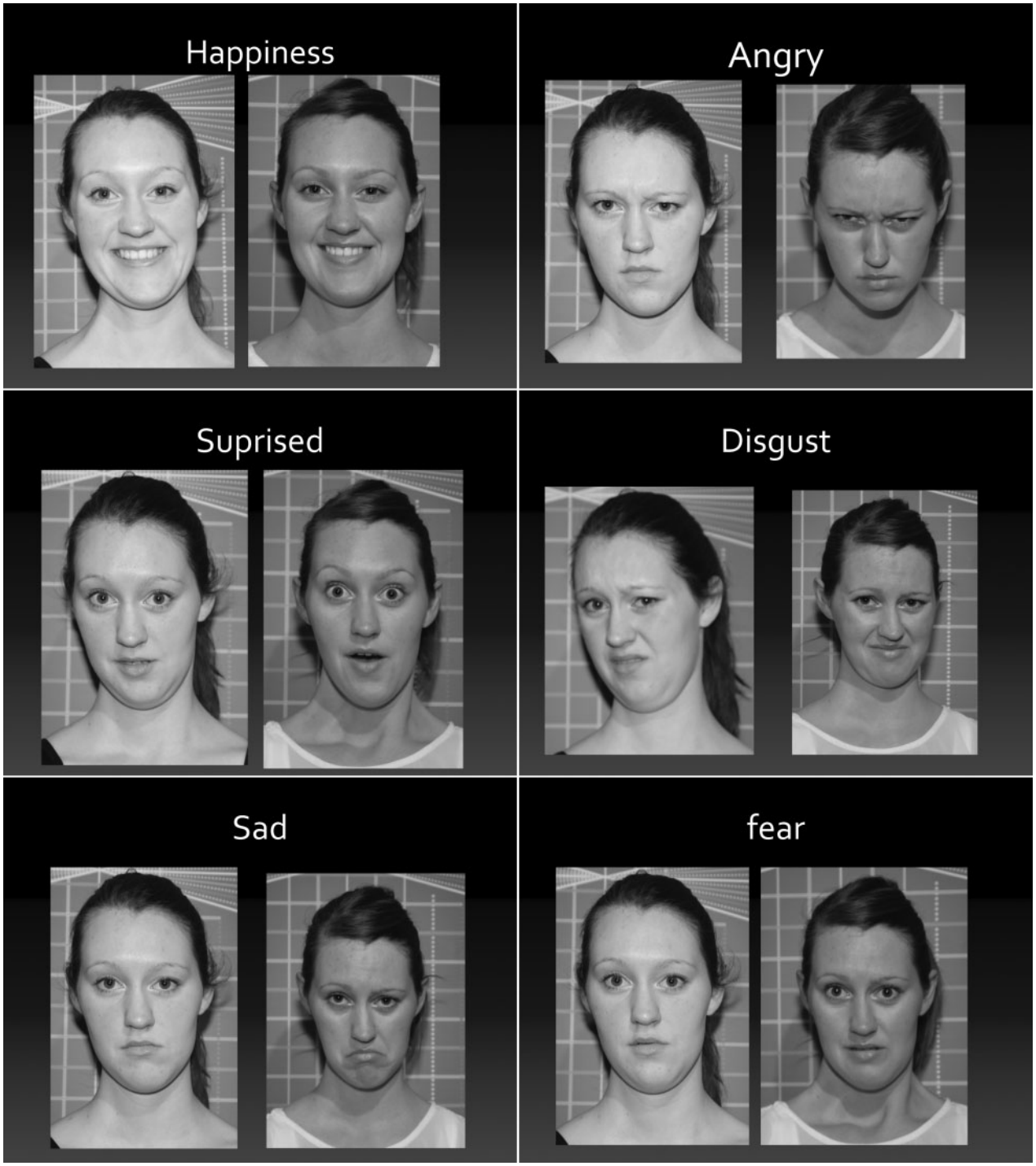

Figure 8 Changes in facial expression before and after treatment.

Table 2 Summary of data: accuracy (%) and average time (second) of the Right–Left Lateralization Test (Later. R and L), Emotion-Recognition Total (Emot. Rec. Total), emotions of happiness and anger, TAS, and BDI

	Later. R	Later. L	Emot. Rec. Total	Happiness	Anger	TAS	BDI
	%	%	%	%	%	%	%
	Second	Second	Second	Second	Second	Second	Second
Treatment 1 day 1	66	94	76	43	57	4.12	13
	2.1	1.6	2.1	2.7	3.2		
Treatment 6 day 87	94	96	100	87	71	2.34	6
	1.1	1.6	1.7	1.4	1.6		

Note: TAS: Toronto Alexithymia Scale; BDI: Beck Depression Inventory on days 1 and 87 after six treatment sessions.

emotions. Lisa suffered from significant depression [Beck Depression Inventory (BDI)][55] and signs of alexithymia were seen [Toronto Alexithymia Scale (TAS); >3.0 is the cutoff for the presence of alexithymia].[39]

After the therapy, laterality recognition on the left and emotion recognition both significantly improved (Table 2), whereas the TAS score and the BDI was greatly reduced. Lisa's painful episodes were significantly less frequent and less intense, and she was able to reduce her dosage of Gabapentin to once daily. Lisa's facial expressions were also improved noted to be significantly more distinct and more symmetric (Fig. 8).

Conclusion

The current paper proposes that display of emotions through facial expression and recognition of emotions in other people are particularly important for interpersonal communication. A healthy person can display 7000–8000 different facial expressions. However, diseases such as chronic facial pain and temporomandibular dysfunction, as well as facial paresis or Parkinson's disease, can impair the display and recognition of emotions. In theory, the changes in the perception process of the affected part of the body occur in the brain (i.e. smudging, neuronal representation). A well-functioning facial reflex provides an important basis for accurate interpretation of emotional facial expressions and right–left discrimination. Functional disorders can be discovered through a focused assessment of findings (illustrated assessments). Integrating tools such as right–left lateralization, mental practice, face mirroring, or EmoRec-Cards into existing neuro-musculoskeletal therapies may help clinicians train their patients to recognize emotions and emotional facial expressions. As a consequence, patients suffering from chronic neck pain, headache, and facial pain can have an improved quality of life.

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