**Title of Entry:** Facial EMG indices of empathy in children and adolescents with disruptive behavior disorders

**Innovation:** Children and adolescents with disruptive behavior disorders are an important clinical group in child psychiatry and psychology. A basic property of these disorders is a lack of emotional empathy. This deficit can be diagnosed by analysis of facial expressions in response to negative emotions displayed by others, using trained experts or automated systems. However, these methods have considerable weaknesses. Visual evaluation by experts is time-consuming and rapid facial movements may be missed. A general problem of visual methods is that many facial emotional responses are relatively weak and remain under the visual detection threshold. Using facial EMG, visible and nonvisible responses can be accurately detected with a high time resolution. This application is novel in this field.

**Description:** Disruptive behavior disorders in children and adolescents are a source of growing concern in society and mental health care. These disorders include hostility, disobedience, opposition to authority figures, and little concern for the feelings and well-being of others [1]. They may develop into a repetitive and persistent pattern of aggressive and antisocial behavior and may be a precursor of antisocial personality disorder or psychopathy in adulthood. An important factor underlying these disorders is a lack of emotional empathy (i.e., the ability to understand and share another’s emotional state). Emotional empathy is thought to promote positive behavior such as helping and to prevent or reduce antisocial behavior. Negative behaviors towards others are inhibited by the others’ display of distress cues (expressions of fear, sadness, or anger). Brain imaging studies suggest that dysfunctioning of this inhibitory mechanism depends on abnormalities in brain circuits involving the amygdala and prefrontal structures [2].

Emotional empathic responses are activated by negative emotional expressions of others in which facial expressions play a crucial role. It is thought that mirror neurons in different areas of the cerebral cortex play an important role in understanding others’ emotional states by simulating their emotional expressions. Mirror neurons would thus be involved in the automatic generation of facial expressions identical to those of the observed person [3]. In the normal population and in clinical groups, subnormal facial responses to others’ emotional expressions have been shown to be associated with weak empathic responses. Facial emotional responses might thus be a valuable biological marker of the generation of empathy. In various studies, such responses were evaluated by trained observers and found to be subnormal in several clinical groups. An important methodological problem of this application is that video recordings have to be evaluated frame-by-frame, which is a very time-consuming process. Much progress has been made in the development of automated systems for scoring facial expressions so that this problem would be solved but a more fundamental problem is that weak or moderate affective responses are often accompanied by visually undetectable facial movements [4]. Using surface EMG, even the weakest responses, remaining under the visual detection threshold, can be detected.

The experience and expression of positive and negative emotions can be reliably assessed measuring EMG activity of the corrugator supercilii (involved in frowning) and zygomaticus major (involved in smiling) muscles. Corrugator activity linearly increases with subjective experience of negative emotions (such as fear, sadness, and anger) whereas zygomaticus activity increases with positive emotions (such as enjoyment and positive surprise) [5]. In several age groups of children and adolescents, we have found that activity of these muscles sensitively reacts to evocative film clips showing persons undergoing real-life emotional events. An example of such a recording is presented in Figure 1 which shows dynamic corrugator EMG responses analogous to changes in the emotional state of the principal person in the film. We have now performed several studies in children and adolescents with disruptive behavior disorders and, as illustrated in Figure 2, we found that corrugator responses to film clips displaying negative emotions were subnormal whereas responses to positive emotions did not show abnormalities in comparison with normal children.

We have also studied facial mimicry responses to short-lasting dynamic facial emotional expressions produced by trained actors. Facial mimicry responses are based on automatic overt simulation, or covert imitation, of facial emotional expressions by others. Such responses occur unconsciously, are difficult to suppress voluntarily [6], and rely on activity of the mirror neuron system. Facial motor mimicry is an innate capacity which contributes to the development of empathy in the preverbal years and continues to play a role in later years of life. As illustrated in Figure 3, facial mimicry responses were found to be smaller in children with disruptive behavior disorders than in normal children.

Although this application cannot be considered a technical innovation, we think that the application of facial EMG recordings in these clinical groups is novel and that it may improve individual diagnostics, particularly in young children. Early diagnostics is important since therapeutic interventions may be more successful if they are started early. We are currently also participating in a project investigating whether emotional facial EMG responses to standardized emotional stimuli have predictive value for therapeutical success of Parent Management Training Oregon, a prevailing training program for parents having children with severe behavioral problems. The purpose is to improve treatment success rates by focusing on children with defective empathic skills as diagnosed using EMG measurements.
Title of Entry: Facial EMG indices of empathy in children and adolescents with disruptive behavior disorders

Supporting Material:

Figure 1. Corrugator EMG responses in 382 adolescents during exposure to an emotional film clip in which a boy shows increasing anger and indignation while he is bothered and unfairly treated during a bicycle race. EMG activity during the emotional target episode at the end of the clip is compared with activity during an initial, emotionally neutral, episode.

Figure 2. Corrugator response to presentation of film clips involving a child in a negative (sadness, anger) or positive (happiness) common childhood situation. Children with disruptive behavior disorders (DBD) showed smaller EMG responses during negative emotional situations than normal control children (NC).

Figure 3. Mean corrugator and zygomaticus EMG mimicry responses to film clips (lasting 5.5 s) of dynamic angry and happy facial expressions. Each clip starts with a 2-s period of neutral expression, followed by a 2.5-s period of emotional expression. Arrows indicate apex of dynamic expression.

References

History of dissemination (Authors and bibliographic details are not included for reasons of anonymity)
(2) Facial EMG and heart rate responses to emotion-inducing film clips in boys with disruptive behavior disorders. Psychophysiology.
(3) Verbal, facial and autonomic responses to empathy-eliciting film clips by disruptive male adolescents with high versus low callous-unemotional traits. Journal of Abnormal Child Psychology.