Output properties for validated static inputs in a facial affect recognition system

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***Abstract*—Recognition of facial affect has marked importance in proper social functioning. In several psychiatric conditions (e.g. autism spectrum disorder, antisocial personality disorder) major alterations in social functions are present, and in patients diagnosed with these conditions, there is a marked bias in the interpretation of facial affect. Computer-guided help in the interpretation of facial affect might be used for later therapeutic interventions. In the present study response characteristics of emotion recognition are shown for validated images in a facial affect recognition system (Noldus FaceReader).**

I. Introduction

Advances in the facial affect recognition in recent years [1,2] led to the development of facial affect recognition systems, among them the Noldus FaceReader [3]. There is a growing interest for facial affect recognition systems in the field of computer sciences, market research, education and basic psychology/psychiatry research [3]. Recognizing facial affect is a major component of social interactions, and mirrors several elements of the social recognition procedure. Originally, six basic universal emotions (anger, disgust, fear, happiness, sadness, surprise) were described as pan-cultural elements of facial affect [4]. In principle, the perception and interpretation of facial affect in humans is a highly complicated process, involving a time-dependent multilayer mechanism for each emotion [5].

Additional to its importance in the interpretation of human communicative signals, facial affect recognition systems might be considered as “social prosthetics” in vulnerable individuals [6]. Two major psychiatric conditions affecting emotion recognition is autism spectrum disorder and antisocial personality disorder [7,8]. In these cases, long-term misinterpretation of social signals might result in a more pronounced social dysfunction. In the case of autism spectrum disorder, a long research line suggested the alteration in the recognition of facial affect [9,10], and in recent years, direct therapeutic efforts were outlined to help affected individuals with the training of facial affect recognition [11,12]. In the case of antisocial personality disorder, literature data suggested a marked alteration in the recognition of distinct emotions [13], and alterations are also present in the so called antecedent conditions (adolescents diagnosed with conduct disorder and psychopathic traits) [14-17]. Dadds and colleagues argue that targeting bias in the recognition of facial affect might help in the therapeutic process in children and adolescents with conduct problems [18,19]. This is especially important as no “A”-level therapeutic evidence is present so far in this condition [20].

To our best knowledge, facial affect recognition systems were not used previously in adolescents with conduct problems. The Noldus FaceReader system was specifically developed for detailed screening of facial expressions. In our research line, the facial expressions of adolescents with conduct problems will be determined with the help of the system during different stimuli. As no prior publications were found in the specific field, we needed preliminary data with the system to clarify our further experimental design. Albeit the external validation of the FaceReader for static inputs was published earlier [21,22], two major questions emerged. First, the authors of the above papers did not use validated facial expressions as input stimuli. E.g., the authors did use a large number of input images, but a considerable amount of disagreement between the human labeling of the images were present, thus further clarification was needed with validated images. Second, the FaceReader system is capable for detailed descriptive responses of the images, but only the first order emotion matrix (the highest order value) was published.

The aim of the present study was to describe the detailed response profile of the FaceReader system in a well-known stimulus database, the Facial Expression of Emotion: Stimuli and Test (FEEST) [23]. These data were markedly important in our research line: the majority of papers in our specific field used this (or slightly modified versions of the above) specific test for affect recognition, and most importantly, our prospective research is based on the usage of these specific images as stimuli for adolescents during the FaceReader application.

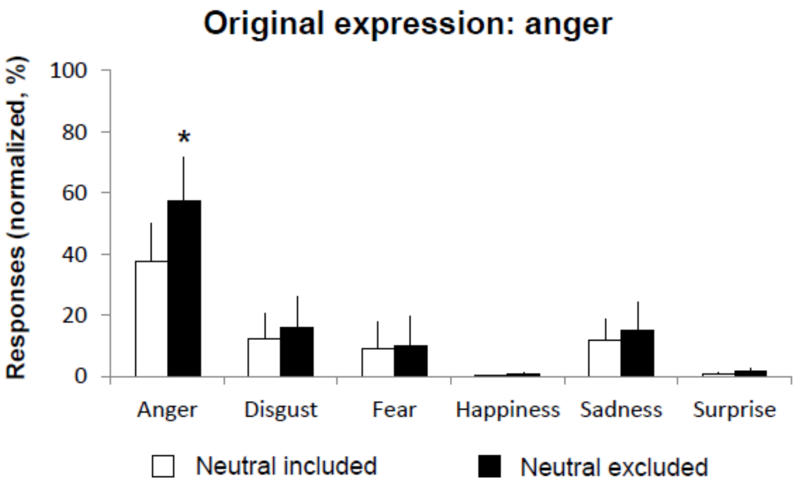

Fig. 1. Normalized responses (%) given to pictures including facial expressions of anger. Data are presented as mean and SEM. White bar, neutral responses included, black bar, neutral responses excluded. *, significantly different from other corresponding responses (p<0.05).

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II. METHODS

The research “Dimensional approach in externalization disorders” was approved by the Scientific and Research Ethical Committee of the Hungarian Medical Research Council (ETT-TUKEB). The present paper describes the preliminary technical results what was necessary to establish research with FaceReader in adolescents with conduct problems. The FEEST Emotion subtest is based on the six universal emotions described by Ekman and colleagues [4,23]. The following six emotions were present on formerly validated pictures: anger, disgust, fear, happiness, sadness, surprise. The images contained different facial affect presentations originated from six women and four men. The recognition of the emotional content within these images had high discriminative value, e.g. in healthy adolescents both better than the average or worse than the average responses could be easily considered [16,17]. The Noldus FaceReader system compares facial expressions to statistically defined basic patterns [3]. Albeit the FaceReader 5.0 is capable to analyze dynamic (and real-time) stimuli, in this paper the response properties of the system for these images was described. Within the FaceReader, gender and age were not adjusted in the present study. The image recognition option was used. The detailed response patterns were analyzed. Response data were normalized (e.g., a picture expressing sadness was considered by the system as sadness in 63.79%, fear in 32.01%, disgust in 3.54%, and

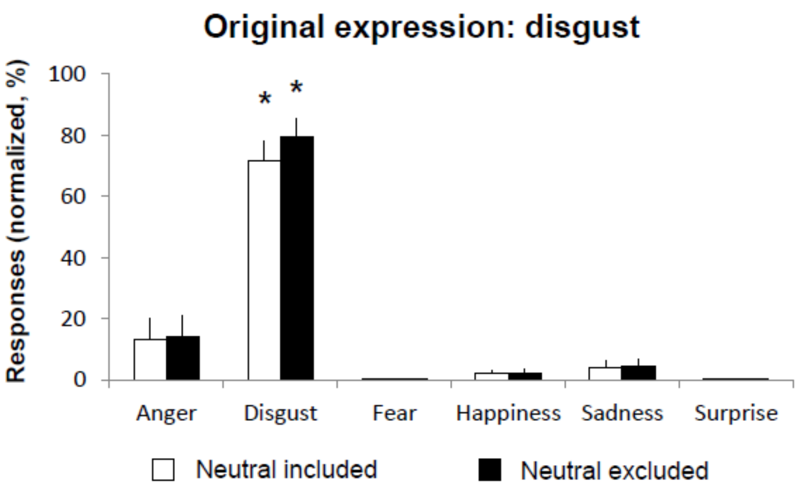

Fig. 2. Normalized responses (%) given to pictures including facial expressions of disgust. Data are presented as mean and SEM. White bar, neutral responses included, black bar, neutral responses excluded. *, significantly different from other corresponding responses (p<0.05).

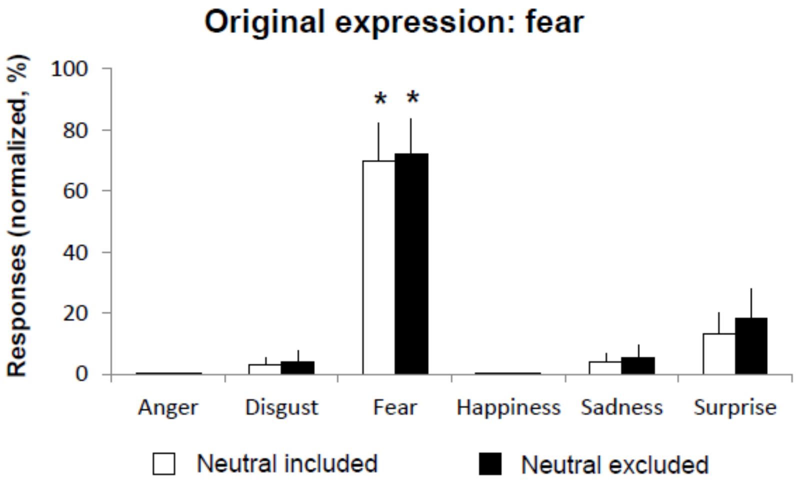

Fig. 3. Normalized responses (%) given to pictures including facial expressions of fear. Data are presented as mean and SEM. White bar, neutral responses included, black bar, neutral responses excluded. *, significantly different from other corresponding responses ($p<0.05$).

surprise in 0.66%; without anger or happiness in the response). From the 60 images, in 8 cases the facial expression was not characterized by the system. Thus, the final analysis included 52 stimuli pictures (anger: 8, disgust: 9, fear: 9, happiness: 9, sadness: 10, surprise: 7). In the first model neutral responses were not considered, and in the second model neutral responses were also considered. The first order stimulus-response matrix was also considered.

Statistica 7.0 program was used to compare the responses given to each group of emotion stimuli with ANOVA for repeated measures (a stimulus picture was analyzed in relation with the possible outcome responses of emotions). Newman-Keuls post hoc comparisons were also run where appropriate.

III. Results

In the case of anger stimuli (Fig. 1.), a significant effect of emotion responses were observed ($F_{(5,35)}=4.446$, $p<0.004$), while the effect was considerably lower after including neutral emotion responses ($F_{(6,42)}=2.547$, $p<0.04$). Anger responses were significantly higher in intensity compared to the other responses in the analysis which did not include neutral responses, but was not significant in the post hoc analysis including neutral responses.

In the case of the other emotions, discrimination was significant in both models (Fig. 2-6). The most

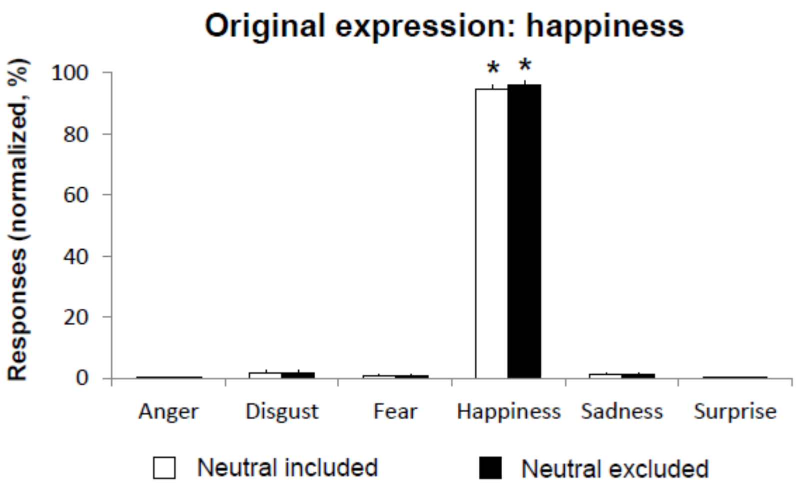

Fig. 4. Normalized responses (%) given to pictures including facial expressions of happiness. Data are presented as mean and SEM. White bar, neutral responses included, black bar, neutral responses excluded. *, significantly different from other corresponding responses ($p<0.05$).

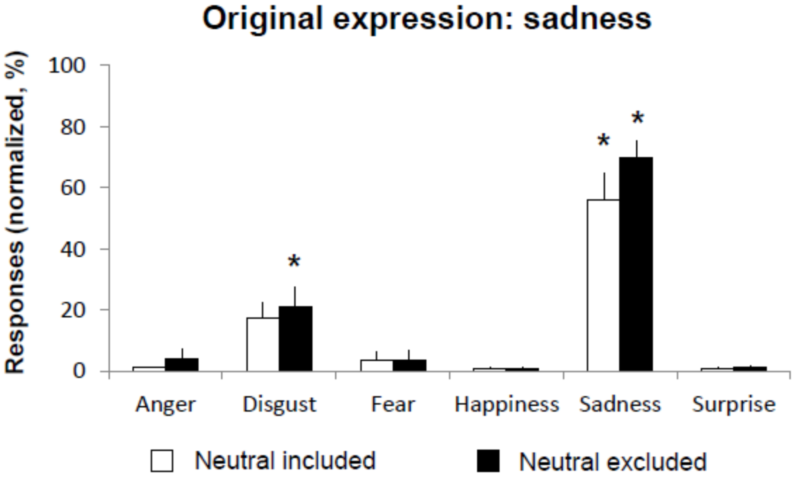

Fig. 5. Normalized responses (%) given to pictures including facial expressions of sadness. Data are presented as mean and SEM. White bar, neutral responses included, black bar, neutral responses excluded. *, significantly different from other corresponding responses (p<0.05).

pronounced discrimination was present in the case of happiness (non-neutral: $F_{(5,40)}=3471.076$, $p<0.0001$; neutral: $F_{(6,48)}=1742.114$, $p<0.0001$). The discrimination of recognizing disgust (non-neutral: $F_{(5,40)}=50.472$, $p<0.0001$; neutral: $F_{(6,48)}=38.378$, $p<0.0001$) and surprise (non-neutral: $F_{(5,30)}=31.880$, $p<0.0001$; neutral: $F_{(6,36)}=36.453$, $p<0.0001$) were similar to each other; while high sensitivity of recognizing fear was also present (non-neutral: $F_{(5,40)}=15.195$, $p<0.0001$; neutral: $F_{(6,48)}=14.908$, $p<0.0001$). In the case of sadness, the effect of neutral components were marked, but in both models significant effect was present (non-neutral: $F_{(5,45)}=39.869$, $p<0.0001$; neutral: $F_{(6,54)}=12.527$, $p<0.0001$).

Within the emotion matrix, the correct overall first-order labeling was 82.5%, while the following order emerged: anger (62.5%) < fear (66.7%) < surprise (85.7%) < disgust (88.9%) < sadness (90%) < happiness (100%). The order remained similar when the failures in face-reconstruction were calculated within the analysis.

IV. Discussion

The main results of the present study were the following. First, the overall performance of the FaceReader 5.1 for selected validated images (stimuli used in the FEEST procedure) was 82.5%, and significant for all six basic emotions. Second, the worst performance was observed in the case of anger, while the highest discrimination was present in the case of happiness. The

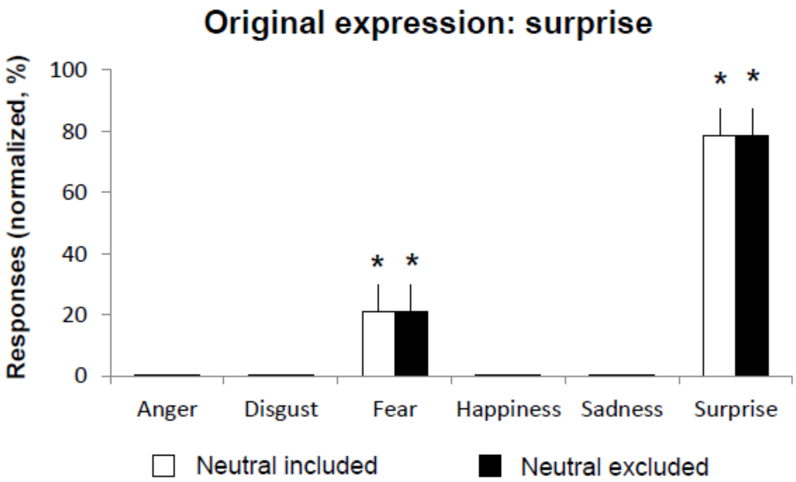

Fig. 6. Normalized responses (%) given to pictures including facial expressions of surprise. Data are presented as mean and SEM. White bar, neutral responses included, black bar, neutral responses excluded. *, significantly different from other corresponding responses (p<0.05).

inclusion of neutral responses did not result significant output changes. The main advantage of the system additional to automated analysis was the possibility to analyze complex pattern of expressed emotions.

In a facial expression analysis set based on a neuro-fuzzy network [24], overall responses were similar to what we have seen as overall result. Unfortunately, detailed results in relation with distinct emotions were not reported in the above paper. Similar to our results, Busso et al also reported higher sensitivity to happiness compared to anger recognition [25]. In their early paper geometry-based and Gabor-wavelet based methods were compared in the recognition of facial affect [26]. Unfortunately, only overall data were published, while the geometry-based method resulted about 73%, and the Gabor-wavelet method resulted about 93%, again corresponding to our results. Interestingly, the authors report that these results were acquired when the images of fear were removed from their database, as only about 80% agreement was in between the opinion of healthy individuals in the case of images representing fear. In a study where FaceReader was tested in relation with EMG activity, the highest correlation was achieved between the activity of musculus zygomaticus activity and happiness labeling (r=0.72), while smaller but still significant effect was achieved in the case of musculus corrigator activity and anger expression (r=0.55) [27]. Importantly, the EMG activity of these two muscles and the expression of fear were not correlated with the EMG results. One can hypothesize that the expression of fear was not correlated because of technical issues (the state of the two above muscles does not properly represent the condition of being in fear), albeit the recognition of fear is generally more complicated in the general population. In our previous study addressing adolescents without any psychiatric conditions, we also found that the success of recognizing fear was the lowest among the six basic emotions, using the FEEST paradigm [17], and this effect was also present in adults [13]. Overall, there are general differences in the sensitivity of recognizing distinct emotions in humans [5], and somehow this effect is still present in artificial systems.

As described in the introduction, facial affect recognition might have major importance in the pathogenesis in certain psychiatric disorders [7,8]. Alterations described in the working of the amygdalo-prefrontal systems were repeatedly described both in human studies [28-32] and in animal models [33-34], and the amygdalo-prefrontal system is also crucial in the processes interpreting facial affect [5]. Still, it is also possible, that direct therapeutic processes targeting facial affect recognition [11,12,19] might also have major effect not only at behavioral level but also directly on the amygdalo-prefrontal working [35]. In this respect, further studies are needed to test this effect.

The limitation of our study that only a circumscribed number of images have been selected for the present paper, and only static inputs were used. All the images used in the FEEST Emotions subtest were tested [23], and previous studies were already present to test the rough validity of the system [21,22]. In our study a more detailed response map was outlined. On the other hand, we did not plan to include moving objects in the first step, but later on validated stimulus material that part also should be clarified.

In a further step, we would like to assess the facial expression profile in clinical adolescents with different externalization problems, and also, we also would like monitor their facial expressions via FaceReader. The stimuli were selected on prior experience in relation with tests of facial expressions. As we stated above, the FEEST procedure was also used in our earlier works understanding emotion recognition patterns in relation with conduct problems in both healthy and clinical adolescents [16-17], additional to core publications in antisocial development [13-15]. Three major advantages can be outlined with the usage of these specific stimuli. First, the recognition pattern can be compared with the responses of human responders. Second, the FEEST material can be used in further experiments as experimental stimuli, while the facial emotion patterns within the responders can be analyzed automatically with the FaceReader setup. Third, selected FEEST stimuli can be used for mimicking certain emotional content in adolescents, and the expressions can also be analyzed. Thus, additional to the further validation of the static input surface of the system, specific knowledge of the stimuli via the FaceReader interface was acquired; this information might also be used in the interpretation of the results of the ongoing experiments based on the FEEST procedure.

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