Further ‘in silico’ validation of a facial affect recognition system

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***Abstract*— The recognition of human facial affect has crucial importance in social communication and proper social functioning. In certain psychological and psychiatric conditions, the recognition of facial affect and the overall social functioning are also impaired. In recent years, social prosthetics occurred, giving a possibility for later therapeutic applications in these conditions. In the present paper, further characterization of a facial affect recognition system, FaceReader is described, focusing on three basic emotions: anger, fear, and happiness. With the usage of controlled expression intensity and laterality, present data indicate that the above system is capable for discriminating basic emotions and is sensitive for stimulus intensity. In the case of anger, no major effect of laterality was present, but the system was sensitive for laterality in the case of fear and happiness.**

Keywords: Affect Recognition System, Anger, Facial, Fear, Happiness, Social.

I. Introduction

In the late sixties of the last century, six basic universal emotions were described (anger, disgust, fear, happiness, sadness and surprise) as pan-cultural elements of facial affect [1]. The perception and interpretation of facial affect in humans is a complex multilayer mechanism for each emotion [2]. A growing interest for facial affect recognition systems occurred in the field of education, market research, psychology and computer sciences [3-5], but the usage of these systems as “social prosthetics” in vulnerable individuals was also suggested [6]. The discrimination of these basic facial emotions is markedly important in the social functioning of the individual. Impairment in the recognition and the interpretation of these patterns might accompany different psychiatric conditions, among them autism spectrum disorder, schizophrenia and antisocial development [7,8]. So far it is unclear whether specific recognition deficits might occur in specific psychiatric conditions, but the usage of these systems might have major potential diagnostic and therapeutic effect in the above psychiatric conditions [6]. Our original research line targets adolescents with externalization problems, and this population is vulnerable towards antisocial development. A sensitive issue within this population is the marked difficulty in the recognition of fear [9-11]. This specific impairment might result controversies in dyadic encounters, e.g. the misinterpretation of the occurring fear on the face of the opponent might result the continuation of a physical fight in adolescents. Targeted therapeutic inventions were initiated to decrease the level of “fear blindness” in adolescents with externalization problems [12]. Using validated systems capable for automatic detection of facial affect in adolescents with conduct problems might also outline major alterations responsible for behavioral patterns. Thus, for the above reason, only facial emotion recognition systems with established and detailed characteristics can be used in clinical studies.

The Noldus FaceReader system was designed for fast and reliable automated analysis of facial expressions [13]. The external validation for static inputs on a large number of input images was performed earlier [14,15], and the system was able to discriminate effectively according to the six basic emotions. In the above papers, only the first-order emotion matrices were described. Later publications on validated static inputs also confirmed the usability of the system [16,17], and in a recent paper the detailed response field for validated static inputs was also described [18]. Still, certain aspects of the system were not described, what might be important for later interpretation of using the system in patients with different psychiatric conditions. Validated databases were sensitive to the nature of emotion, but the intensity of the emotions was not clarified. Additionally, the above papers used images with faces in frontal position, thus to our best knowledge, neither the intensity nor the laterality of the visible faces were controlled in the above studies. Basically, a new set of pictures with controlled intensity and laterality might be appropriate for the above trial. Instead of these controlled experiments, a set of ‘in silico’ faces were created to test the effect of laterality and intensity in the Noldus FaceReader system.

The aim of the present study was to describe the emotion specific responses onto stimuli with controlled intensity and laterality on three different emotions: anger, fear and happiness. A marked effect of expressed emotion intensity was suggested, while no effect was suggested in the case of slight laterality. In our previous study, the system was less sensitive in the recognition of anger, and the most sensitive in the recognition of happiness [18]. The recognition of fear has a major importance in antisocial development [9-11], as described above, thus we also studied the detection profile on expressed fear.

II. METHODS

In the present set of experiments, facial masks were generated (with different expressed emotions) in the free version of the software FaceGen Modeller 3.5 (Singular Inversions). Sample images were presented in Fig. 1 and Fig. 2, respectively. In the first set of the images, a frontal view of the images was present (Fig. 1), while a standardized lateral view was applied in the second set of images, with a moderate laterality of 20 degrees (Fig. 2).

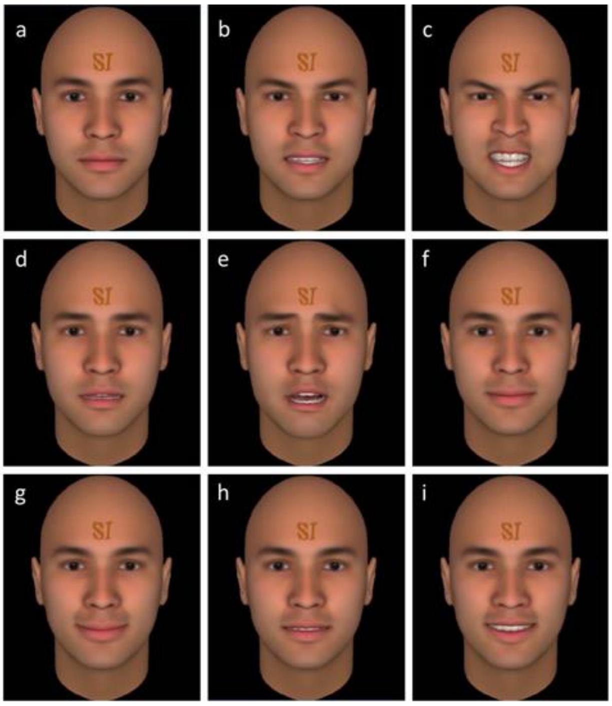

Fig. 1. Sample frontal artificial images from the FaceGen Modeller; a, neutral; b-c, anger low and high intensity; d-e; fear low and high intensity; f-g, happiness (mouth closed), h-i, happiness (mouth open) low and high intensity.

The same set of artificial masks was applied in both camera positions. This procedure was selected in order to establish full controllability and standardization of the images. Additional to the images expressing neutral emotional content, the following emotion intensities were modulated: anger, fear, happiness. As it was described earlier, the present paper was based on earlier observation with validated, standardized images. From the six basic emotions, images expressing anger, fear and happiness were selected. With the FaceGen Modeller, the emotional content was selectively modified in 0.1 steps (10 percentage) between neutral values and maximal expression of the given emotions. In the case of happiness, both open and closed mouth versions were tested. The average responses for 0.1-0.5 intensities were considered as low intensities, while 0.6-1.0 emotional intensities were considered as high intensities. Altogether, 110 images were analyzed by the means of the FaceReader 5.0 program. The detailed emotional responses for a given image were normalized, and neutral responses were also calculated [11]. In the present paper, emotion-specific responses were compared.

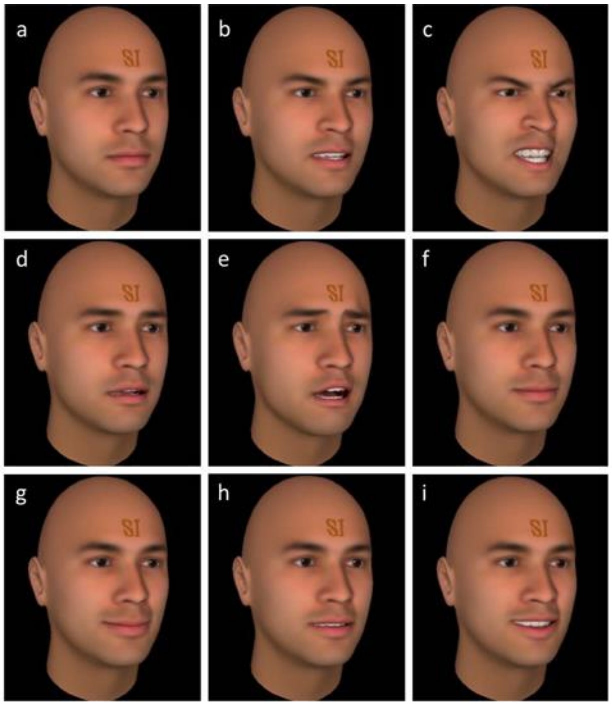

Fig. 2. Sample lateral artificial images from the FaceGen Modeller; a, neutral; b-c, anger low and high intensity; d-e; fear low and high intensity; f-g, happiness (mouth closed), h-i, happiness (mouth open) low and high intensity.

Statistical analysis. Statistica 7.0 program was used for the analysis, GLM model was applied. Data are expressed as means and SEM (Standard Error of the Mean). Laterality (frontal vs. lateral) was used as repeated variable, while the intensity of affect (low vs. high) and the interaction between laterality and intensity was also calculated. Newman-Keuls post hoc comparisons were run where appropriate, $p<0.05$ was considered as significant difference between groups.

III. RESULTS

In the case of anger stimuli, a significant effect of emotion intensity responses were present ($F_{(2,14)}=6.670$, $p<0.01$), while no effect of laterality was observed ($F_{(1,14)}=3.138$, $p<0.1$). Interestingly, higher intensity on the expressed masks was accompanied by higher detection responses only in the case of lateral view (Fig. 3).

In the case of fear stimuli, a significant effect of emotion intensity responses were present ($F_{(2,14)}=10.980$, $p<0.0014$), and marked effect of laterality was also present ($F_{(1,14)}=11.769$, $p<0.005$). Low fear intensities did not differ from the baseline. High fear intensities were properly discriminated in the frontal view (Fig. 4). In the case of lateral view, a marked impairment was visible in the detection.

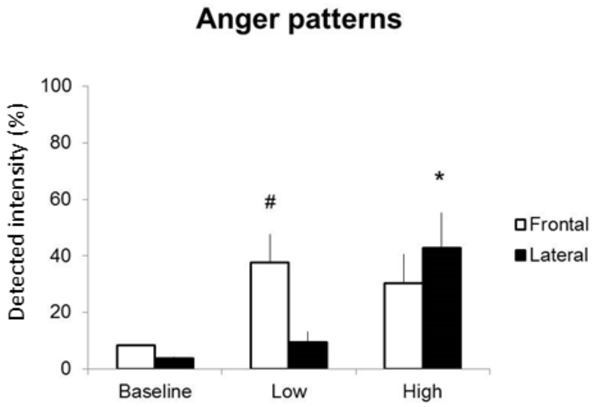

Fig. 3. Anger patterns. Data are expressed as means±SEM. Low, stimulus with low intensity; High, stimulus with high intensity; Frontal, frontal arteficial images; Lateral, lateral view of images (20 degrees); *, significantly different (p<0.05) from baseline; #, significantly different (p<0.05) from frontal view.

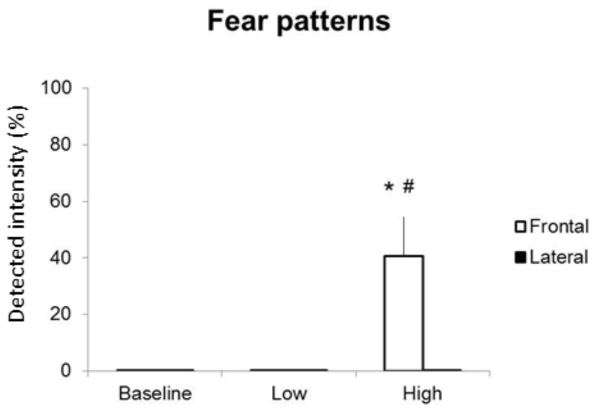

Fig. 4. Fear patterns. Data are expressed as means±SEM. Low, stimulus with low intensity; High, stimulus with high intensity; Frontal, frontal arteficial images; Lateral, lateral view of images (20 degrees); *, significantly different (p<0.05) from baseline; #, significantly different (p<0.05) from frontal view.

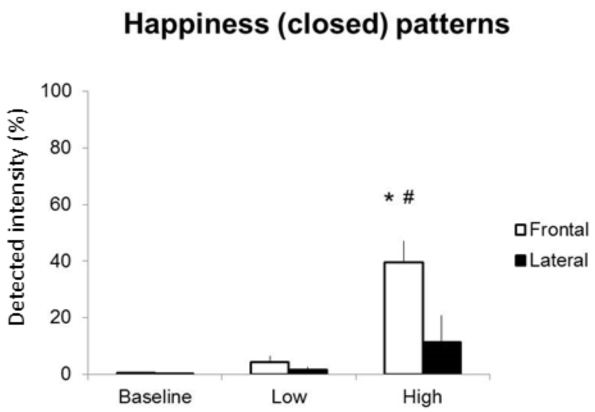

Fig. 5. Happiness (mouth closed) patterns. Data are expressed as means±SEM. Low, stimulus with low intensity; High, stimulus with high intensity; Frontal, frontal arteficial images; Lateral, lateral view of images (20 degrees); *, significantly different (p<0.05) from baseline; #, significantly different (p<0.05) from frontal view.

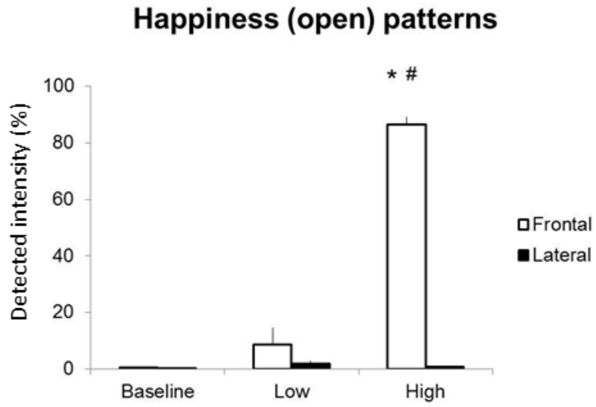

Fig. 6. Happiness (mouth open) patterns. Data are expressed as means±SEM. Low, stimulus with low intensity; High, stimulus with high intensity; Frontal, frontal arteficial images; Lateral, lateral view of images (20 degrees); *, significantly different (p<0.05) from baseline; #, significantly different (p<0.05) from frontal view.

In the case of happiness stimuli, both the effect of closed and open smile was analyzed. In the case of happiness with the mouth closed, a significant effect of emotion intensity responses were present ($F_{(2,14)}=13.994$, $p<0.001$), and marked effect of laterality was also present ($F_{(1,14)}=12.547$, $p<0.004$). Low intensities did not differ from the baseline. High closed happiness intensities were properly discriminated in the frontal view (Fig. 5). In the case of lateral view, a marked impairment was visible in the detection. In the case of happiness with the mouth open, a significant effect of emotion intensity responses were present ($F_{(2,14)}=190.356$, $p<0.00001$), and marked effect of laterality was also present ($F_{(1,14)}=262.603$, $p<0.00001$). Low intensities did not differ from the baseline. High open happiness intensities were properly discriminated in the frontal view (Fig. 6). In the case of lateral view, a marked impairment was visible in the detection.

IV. DISCUSSION

The main results of the present study were the following. First, the system was most sensitive for the detection of ‘in silico’ happiness, especially when the mouth was open during expression. Second, in the case of fear and happiness, the FaceReader was sensitive to the intensity of the stimuli, and the slight lateral view significantly impaired the performance. Third, in the case of anger, no effect of laterality was present, and low intensities resulted high responses in the frontal view.

According to earlier reports, FaceReader has the highest recognition sensitivity in the case of happiness among the basic emotions [14-18]. These studies did not discriminate between closed and open mouth patterns. Our data indicate that happiness with open mouth is a stronger signal to the system, but reliable data can be acquired even with happiness with mouth closed. The closed pattern might also be considered as a state with lower intensity, thus the data outline the sensitivity of the system for different intensities.

In the case of fear, only high intensities were recognized, and the recognition pattern was similar to pattern visible in the case of closed happiness. In humans, among the basic emotions, the most difficult is the detection of fear [19]. Albeit the FaceReader 5.0 system was sensitive to the intensities, slight laterality abolished the effect.

Laterality did not cause problem in the case of anger, albeit slightly modified the detection pattern seen in the case of frontal view. This is a differential effect, and can be taken into account for later analysis. E:g., when someone rotating the head during the experiment, the proportion of angry responses might relatively get increased compared to the proportion of other responses. In the case of externalizing adolescents, where comorbid attention deficit hyperactivity (ADHD) might be present, the above effect might be taken seriously [20].

The limitation of our study was that 'in silico' faces were used for testing the effect of stimulus intensity and laterality. Further studies might include validated databases (both in terms of emotion specificity, intensity and laterality), but at present, we have no information on such a database. On the other hand, this computerized method was able to establish standardized measures in terms of angle and intensity, which is definitely robust (if possible) effort from a human presenter.

In conclusion, these data suggest that stimulus intensity might be detected with the FaceReader 5.0 system, and happiness is the most sensitive among the emotions studied. Frontal view is necessary to acquire the above result, and the effect of even slight laterality must be taken into account.

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