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ANALYSIS OF FACIAL EXPRESSIONS IN PATIENTS WITH SCHZIOPHRENIA, IN COMPARISON WITH A HEALTHY CONTROL - CASE STUDY

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SUMMARY

Introduction: *Deficits in area of communication, crucial for maintaining proper social bonds, may have a prominent adverse impact on quality of life in patients with schizophrenia. Social exclusion, lack of employment and deterioration of family life, may be consequences of aggravated social competencies, caused by inability to properly exhibit and interpret facial expressions. Although this phenomenon is known since first clinical descriptions of schizophrenia, lack of proper methodology limited our knowledge in this area. Aim of our study was to compare facial expressivity of the patient with schizophrenia, and the healthy individual.*

Methods*: 47-years old patient suffering from schizophrenia, and 36-years old healthy individual were invited to participate in our study. They underwent the examination in Human Facial Modelling Lab in Polish-Japanese Institute of Information Technology in Bytom (Silesia, Katowice). Both participants were presented with two video materials, first one contained different facial expressions, which they had to imitate. Second one a part of comedy show, during which spontaneous reactions were recorded. Acquisition of facial expressions was conducted with marker-based technology of modelling. Obtained data was analyzed using Microsoft Excel.*

Results and conclusions: *An overall facial expression intensity, expressed as an average value of distances traveled by markers during shifts from neutral position was higher in case of a healthy participant during both part of the study. The difference was especially visible in case of an upper half of the face. Utilization of marker-based methods in analysis of human facial expressions seem to be reliable and remarkably accurate.*

Key words: *schizophrenia - facial expressions – emotions - cognition*

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INTRODUCTION

In recent years, a great deal of studies shed light on many aspects of pathogenesis and treatment of schizophrenia. However, despite that significant progress, some therapeutic issues still remain unsolved, especially concerning social functioning of patients. Deteriorating mental health, positive and negative symptoms as well as cognitive dysfunction, have a prominent, adverse impact on quality of life of those affected, making them more susceptible to psychosocial stressors. One of the most important factors affecting patients with schizophrenia is social exclusion in various life domains (Lauber *et al.* 2004; Wysokiński, 2016). Although, this phenomenon is described in many disorders, in schizophrenia it is exceptionally important, due to significant implications it has on development, prognosis and treatment of the illness(Couture *et al.* 2006). It is primarily caused by deficits in the area of communication, which is crucial for maintaining satisfactory social functioning. Facial expressions play an essential role in communication, providing variety of information about the person and context, simplifying mutual apprehension of interlocutors and help regulate of one's reactions to other people (Schwartz *et al.*, 2006). Aggravated social competencies in patients, caused by inability to properly exhibit and interpret facial expressions and emotions behind them, lead to difficulties in establishing and sustaining healthy social bonds (Martyniak *et al.*, 2016). Consequently, it cause development of disturbances in social functioning, such as problems with maintaining employment or deterioration of family live (Couture *et al.*, 2006). Flat affect, especially in the field of encoding facial expressions of emotions, have been acknowledged since the first clinical descriptions of schizophrenia by Bleuer and Kraepelin (Schwartz *et al.*, 2006). However, shortage of proper, accurate methodology, caused relatively small amount of research in this area. Available literature agree, that patients with schizophrenia manifest a dissociation between verbal and affective messages (Gottheil *et al.* 1976), and overall facial expression is either lowered (Schneider *et al.*, 1990) or inappropriate, with presence of atypical muscle activity (Kohler *et al.*, 2008). The facial expression is primarily a motor behavior, and it can be divided into two types. First one, is voluntary facial expression, unrelated to the emotional state, which involves observation of f.e. still picture, movie or another individual's face and mimicking expression, with utilization of mirror neuron system (MNS) (Ekman, 2003; Rizzolatti and Craighero, 2004). Second one, involuntary facial expression, is evoked by an emotional state of a patient, through the pyramidal and extrapyramidal circuits (Ekman, 2003). Furthermore, Aghevli et al. found out that despite lowered expressivity in schizophrenia, subjective experience of emotions remains intact (Aghevli *et al.*, 2003). Therefore flat affect may be regarded as a primarily motor abnormality.

In the last century, facial expressions in schizophrenia have been rated with a variety of methods, including assessment by extensively trained beholders (Ekman and Friesen, 1971; Rosenthal, 1980), examination of facial electromyographic (EMG) activity (Fridlund and Izard, 1983) and computer based analysis of facial action (Schneider *et al.*, 1990). Development of accurate and objective methodology, was based on studies conducted by Lynn and Lynn in 1940 (Lynn, 1940) and 1943 (Lynn and Lynn, 1943). They developed a specially constructed camera system, and recorded the movements of specific facial points, measuring distances between them afterwards. This method was improved in 1966 by Heimann & Lukacs (1966), who projected each recorded frame on a glass plate with a set of coordinates, what allowed them to determine the exact location of each point in each frame. Although fairly accurate, their methodology did not allow analysis of patients' faces in a real time. The most popular method at the moment is FACS (Facial Action Coding System) developed by Ekman and Friesen(Ekman and Friesen, 1971; Gaebel and Wolwer, 2004). It is based on identification of a single facial muscle movements, defined as "Action Units" (AUs), in six, cross-culturally recognizable emotions - happiness, sadness, anger, fear, disgust and suprise (Ekman and Friesen, 1971). Although popular, assessment procedure in this method is based on trained raters, scoring patients' facial expressions in real time, on a recorded video, what lowers its accuracy and may lead to inter allia confirmation biases[1]. Recently developed techniques of the facial expression capture, are based on a reconstruction of a facial surface, permitting a real time analysis of motor performance with a remarkable accuracy. Those methods are divided into two main subtypes. Majority of techniques utilize reflective markers, which allow to track predefined parts of facial surface, and subsequently reconstruct them. On the other hand "markerless" methods, are able to reconstruct facial surface on the basis of video recording alone. Although tracking specific features in those methods, and synthesis of recordings from cameras is much more complex and prone to bias, it is not limited by the quantity of markers that can be applied without losing accuracy (Pęszor *et al.* 2015, 2016). Marker-based methods, are more accurate and simpler, however also more burdensome for a patient. Furthermore, proper placing of reflective markers is crucial for a credibility of an analysis and quality of reconstruction. Too dense grid, sometimes faulty perceived as more accurate, may make it impossible for a computer system to distinguish small markers from other reflections caused by noise or non-perfect conditions (Pęszor *et al.* 2015). Although marker-based methods, despite minor flaws, seem to be a valuable technique for research on an affect display in psychiatry, so far, little research has been conducted on this issue. It was of the interest how accurate, as well as burdensome for patients, would be those methods.

Aim of our study, was to compare facial expression of patient with schizophrenia and healthy control, utilizing marker-based technology in Human Facial Modelling Lab (HFML) of Polish-Japanese Institute of Information Technology in Bytom (Silesia, Poland).

MATERIALS AND METHODS

Presented study, was conducted in May 2017, in Polish-Japanese Institute of Information Technology in Bytom. 47 years old patient suffering from schizophrenia was invited to take part in the study. He started his psychiatric treatment at the age of 26. One of his first hospitalizations took place after a serious suicidal attempt. He was hospitalized several times, the last time at the age of 36. Since that time he has been treated in the outpatient department and his psychiatric state has been relatively stable. At the age of 43 he experienced a mild psychotic exacerbation, but treatment in the hospital was not necessary. During last couple of years his pharmacological treatment consisted of olanzapine 20mg daily and levomepromazine 75mg daily. The patient reports mild chronic psychotic symptoms, i.e. periodic persecutive delusions, and transient anxiety symptoms, which have no impact on his general functioning. The patient is single, lives with his mother, does not work. As a healthy control we invited 35-years old male, married, a father of a 1 year old daughter.

Acquisition of facial expressions, was conducted using Human Facial Modelling Lab (HFML). Subjects, were seated in front of a set of 10 Vicon Bonita cameras (Figure 1; red arrows) arranged into semicircle, allowing for acquisition not only from the front, but also from the left and right half of the face. Similarly, the varied height of cameras' placement, allowed accurate recording of upper and lower parts of the face.

Patients' faces were covered with set of markers (Figure 2), placed in specific locations, predefined in previous studies (Figure 3) (Pęszor *et al.* no date).

[1] Confirmation bias – subconscious tendency to dismiss evidence that does not support one's hypothesis (Rabin and Schrag, no date)

Figure 1. Placement of cameras around a patient in Human Facial Modelling Lab (arrows – Vicon Bonita cameras x10)

Figure 2. Example of marker placement on subjects' face (person presented in a photography was not a participant of the study)

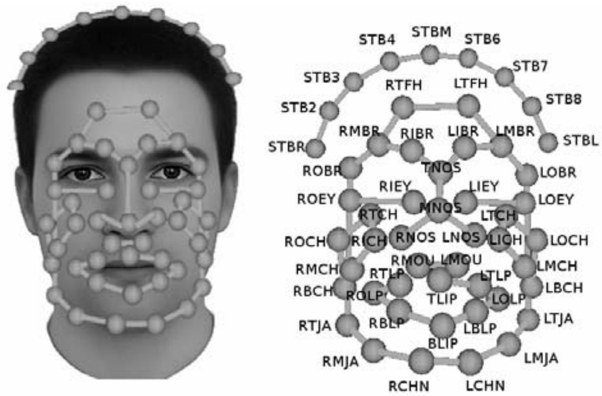

Figure 3. Pattern of marker placement utilized in the study

Markers placed on a face of a subject, are especially reflective for an infrared radiation, which was emitted by Vicon Bonita cameras during acquisition. This allowed cameras – recording only an infrared radiation – to register particularly strong signals from markers as bright spots, on a relatively dark background which reflected only a fraction of an infrared light. Data about a placement and orientation of each camera, obtained during the process of calibration of HFML equipment, allow identification and determination of a precise location of each reflection – marker – in a three-dimensional space (3D). Consecutively each marker is tracked from frame to frame, making it possible to obtain a 3D trajectory of movement for each marked point on the face.

Participants were presented with two types of video material. First one contained prerecorded dynamically changing facial expressions, which they had to imitate. Second one depicted a part of a comedy show, described by both participants as "funny", during which spontaneous reactions were recorded. Acquired data was processed with utilization of the Vicon Blade software, which reconstructed 3D motion of particular parts of participants' faces (Figure 4). Consecutively, raw data concerning positions of each marker, in each frame, was extracted using Microsoft Excel software.

Further analysis of obtained data, was based on a calculation of distances [mm] of shifts from a neutral position, for each marker in relation to corresponding axes (Figure 4), demonstrating an overall intensity of facial expressions. Those values were compared between patient and healthy control. Furthermore, markers representing eyebrows (RIBR, RMBR, ROBR, LIBR, LMBR, LOBR) and mouth (TLIP, LOLP, LTLP, LBLP, BLIP, RBLP, ROLP, RTLP) (Figure 3), were analyzed separately, due to their leading role in expression of emotions (Michael 1999).

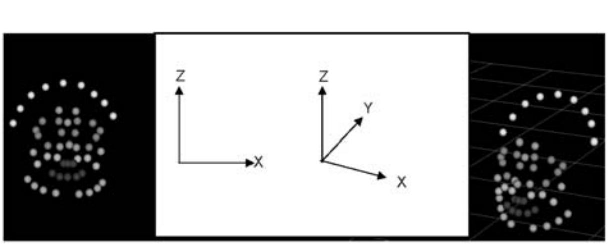

Figure 4. Three dimensional model of participants' faces

RESULTS

Imitation of prerecorded, dynamically changing facial expressions

An overall facial expression intensity, expressed as an average value of distances traveled by markers during shifts from a neutral position (separately for each axis), was higher in case of a healthy participant (Figure 5). It equaled 6.41 mm in relation to the X axis, 9.23 mm to the Y axis and 3.67 mm to the Z axis. Corresponding values in patient with schizophrenia, stood at respectively 5.38 mm, 2.13 mm and 2.35 mm. What is of the interest, differences between average standard deviations were not that explicit (Figure 6).

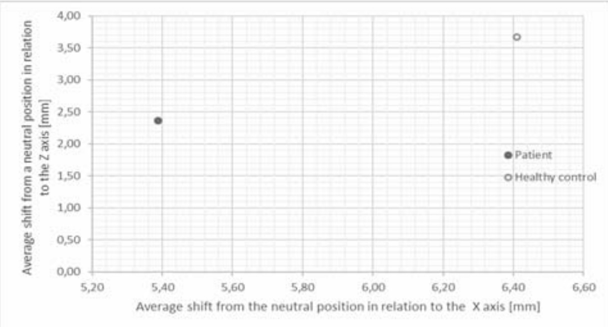

Figure 5. Difference in overall facial expression, between patient and healthy control

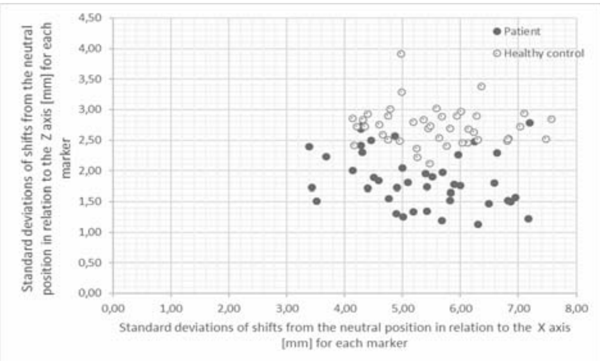

Figure 6. Difference in an overall facial expression, expressed as standard deviations for each marker, between patient and healthy control

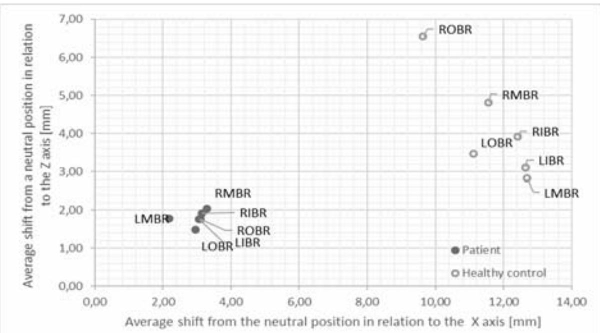

Figure 7. Difference between average shift from the neutral position, for markers embodying eyebrows' movement

Analysis of markers representing eyebrows and mouth demonstrated similar results as the comparison of an overall facial expression (Figure 7, 8). However, the difference was particularly visible in analysis of markers representing eyebrows. Average value of shift for all markers, in healthy participant, equaled 11.69 mm for the X axis, 10.89 mm for the Y axis and 4.1 mm for the Z axis. In patient, those values were respectively 2.96 mm, 6.44 mm and 1.78 mm. In case of mouth, those values were respectively 7.91 mm, 9.88 mm and 4.1 mm for healthy participant and 1.9 mm, 4.8 mm and 2.89 mm for the patient.

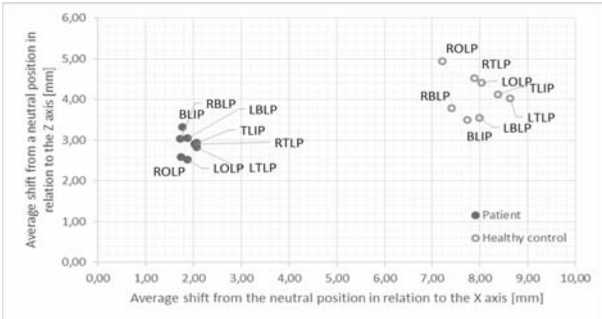

Figure 8. Difference between average shift from the neutral position, for markers embodying mouth movements

Spontaneous facial expressions, induced by a comedy

An overall facial expression intensity was higher in data obtained from a healthy participant (Figure 8), however the difference was noticeably bigger than during imitation of facial expressions. In case of a healthy control, those values equaled 7.66 mm in relation to the X axis, 3.58 mm to the Y axis and 4.30 mm to the Z axis. Corresponding values in patient with schizophrenia, stood at respectively 2.10 mm, 3.90 mm and 1.96 mm.

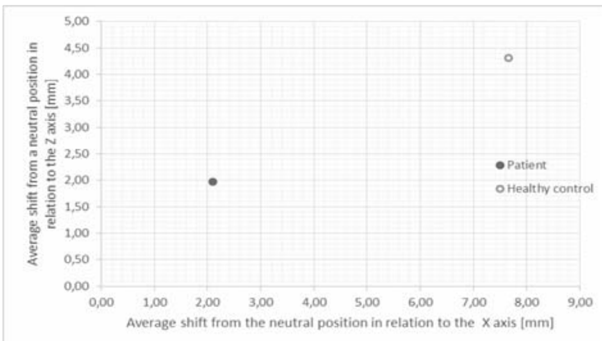

Figure 9. Difference in overall facial expression, between patient and healthy control

There was a visible difference in values of standard deviations, calculated for each marker separately (Figure 9), between the healthy control and the patient. What is of the interest, both cases also differed in a distribution of those values. In case of the patient, all markers exhibited similar variability, and their average standard deviations were between 0.68 mm to 2.14 mm in relation to the X axis, and 0.56 mm to 2.62 mm in relation to the Z axis. In the healthy participant, markers exhibited noticeable differences between each other, in terms of a variability, and their values were between 3.03 mm to 9.02 mm in relation to the X axis, and 2.60 mm to 6.92 mm in relation to the Z axis.

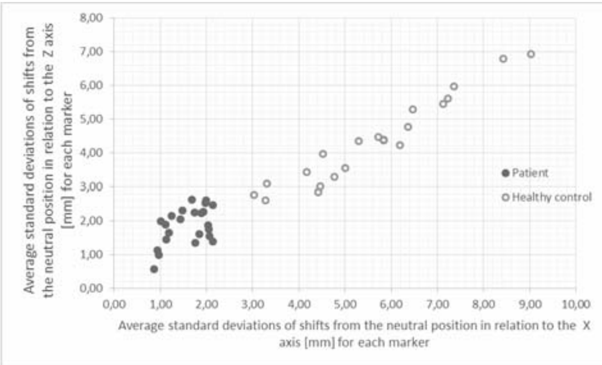

Figure 10. Difference in an overall facial expression, expressed as standard deviations for each marker, between patient and healthy control

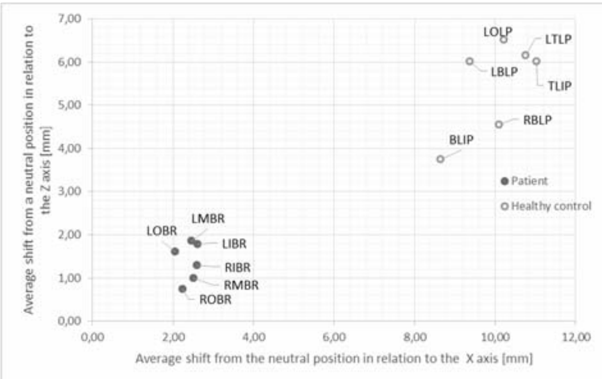

Figure 11. Difference between average shift from the neutral position, for markers embodying eyebrows' movement

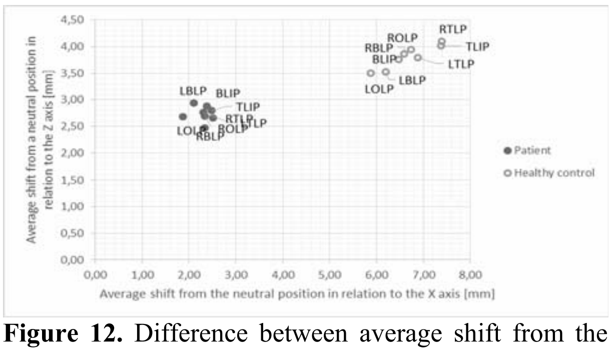

Figure 12. Difference between average shift from the neutral position, for markers embodying mouth movements

Analysis of markers representing eyebrows and mouth demonstrated similar results as the comparison of an overall facial expression (Figure 10, 11). However, the difference was particularly prominent for markers representing eyebrows, where the average value of shift for all markers, in the healthy participant, equaled 10.02 mm for the X axis, 4.05 mm for the Y axis and 5.49 mm for the Z axis. In patient, those values were respectively 2.41 mm, 4.84 mm and 1.37 mm. In case of mouth, those values were respectively 6.69 mm, 3.49 mm and 3.80 mm for healthy participant and 2.29 mm, 3.53 mm and 2.73 mm for the patient.

DISCUSSION

Analysis of facial expressions with utilization of marker based methods, seem to be reliable and remarkably accurate. High fidelity of reconstructed three dimensional models of participants' faces, allows detection of slightest movements, and therefore credible assessment of examined patients. Obtained data is unambiguous, and permit direct comparisons between healthy participants and patients with, for example, schizophrenia.

Outcomes obtained in our study, although preliminary, remain in agreement with findings of other authors (Schneider *et al.* 1990, Aghevli *et al.* 2003, Tron *et al.* 2016), and demonstrated reduced overall facial expressivity, especially in case of an upper half of face. The difference between participants was particularly visible during second part of the examination. Furthermore, during induction of spontaneous reactions, patient's expressivity was more homogenous and repetitive than in healthy participant. Standard deviations for each marker, in case of the patient, were similar for all markers (Figure 9), and much lower than in case of the healthy participant. This observation was particularly interesting, due to the fact that similar effect was not observed during first part of the examination.

CONCLUSIONS

Presented outcomes are preliminary, obtained from the single patient, and compared to the healthy individual. Nevertheless, they seem to confirm findings of other authors, demonstrating decreased facial expressivity of the patient with schizophrenia, as well as lowered diversity of expressions. The second finding, was especially visible during spontaneous reactions. Utilization of marker-based methods in analysis of human facial expressions seem to be reliable and remarkably accurate. Therefore further studies should be conducted, which would provide more significant outcomes due to inclusion of the bigger study and control group.

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Conflict of interest: *None to declare.*

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Drafting of manuscript: K. Wilczyński, K. Krysta, A. Dudek

Critical revision: K. Krysta, M. Krzystanek, K. Wojciechowski, M. Janas-Kozik

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