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Research paper

# Exposure to emotions and postural stability in deaf youth

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ABSTRACT

Introduction: The population of deaf people is a heterogeneous group. Understanding the significant variables that affect motor, socio-emotional and cognitive development sets the direction and quality for subsequent developmental stages and provides the opportunity to select appropriate compensatory methods for deaf individuals.

Aim: The aim of the study was to verify the visual effect of the emotions of joy and anger on one of the dimensions of eye-hand coordination, i.e. postural stability among deaf and hearing youth.

Material and methods: Study subjects: 120 teenagers aged 13–17 years. The test group comprised 60 subjects with profound bilateral sensorineural hearing loss, while the control group comprised 60 hearing junior high school students. The study used a computerised stabilometric platform and photographs sourced from an affective image database Montreal Set of Facial Displays of Emotion.

Results and discussion: In deaf youth, a switch in the stability of the body occurs, as compared to hearing youth. The results obtained indicate the need for the activation of cognitive, emotional and motor resources of deaf people with an area of multiple modalities taken into account.

Conclusions: Human development should be regarded as a continual process in relation to compensatory capacity.

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## 1. INTRODUCTION

During developmental ontogenesis, the central nervous system (CNS) is subject to a flexible process that enables the development of higher functions based on the early acquired experiences or provides compensation in states of developmental deficiency.[1,2] In deaf individuals, there is a specific reorganisation of the areas of both the primary auditory cortex and the associative auditory cortex, with particular emphasis on the temporal plane that is active during the presentation of visual-motor stimuli.[3] For hearing individuals, the aforementioned areas are active during the processing of auditory stimuli, while in deaf individuals, these areas of the cortex are responsible for visual processing.[4]

Motor reproduction of emotional affect observed in people's facial expressions as a subconscious mimetic response during exposure to photographs saturated with emotional.[5,6] On the other hand, an emotion is a subjective mental. Feeling an emotion is usually accompanied by somatic changes, facial, pantomimic expressions and different behaviours.[6,7]

The motor processing of emotional stimuli is closely related to the process occurring between the behaviour and perception, which, in turn, triggers the cognitive and behavioural mental representations of a particular behaviour, which implies the automatic activation of the feedback.[5,6] In the transfer of emotions, affect contagion may occur in a situation where the addressee of an emotional message does not reproduce the expression of the affect-emitting person.[6]

The lack of one of the senses, i.e. hearing, is directly reflected in the need for the adaptation of the remaining senses to the deficiency represented by the inability to receive and interpret auditory impressions.[8] Research into visual perception in deaf individuals indicates the activation of the dorsal-visual pathway during tasks requiring the activation of visual attention. This functional change indicates that in the absence of sensory arousal as regards the auditory sense, a transformation occurs in the neurocognitive system.[9]

The relationship between hearing and motor development is based on the structural and functional development of the auditory organ and its integration with the CNS.[10] However, a prerequisite for harmonious psychomotor development is the proper integration of all the senses. The earliest maturing senses that are co-involved in the sensorimotor integration include the priorioceptive, kinesthetic and vestibular senses.[11] The activity of standing in order to maintain a stable posture involves the integrated action of sensory systems, i.e. the visual system, the vestibular system with the executive system and the osteoskeletal system.[12]

The lack of early stimulation of the sense of hearing leads to abnormal changes in the CNS. A change occurs in the activation of individual areas of the brain when receiving sensory information coming from different sources. Sensory depletion results in functional reorganisation in the auditory system.[13]

## 2. AIM

The overall aim of the study was to verify the visual effect of the emotions of joy and anger on one of the dimensions of eye–hand coordination, i.e. postural stability among deaf and hearing youth.

## 3. METHODS AND MATERIALS

The study included 120 participants (youth from the Maria Grzegorzewska Special School and Education Centre for Deaf Children in Olsztyn and from the Centre for Audiology and Phoniatrics at the Regional Specialised Children's Hospital in Olsztyn) with profound bilateral sensorineural hearing loss. The control group included junior high school students from the Commune Junior High School in Gietrzwałd. Both the test group and the control group comprised 60 respondents aged 13–17 years each. The tests were conducted at the above-mentioned facilities.

### 3.1. Clinical method

The method for performing the test on a computerised stabilometric platform coordination CQStab2P-vUSB-1203 was conducted as follows: the subject was standing on the platform with tensometric sensors placed in the corners to record the central pressure of the feet on the platform surface (representing the projection of the load centre on the base plane) and its movement in the sagittal axis $X$ in the left–right direction, and in the frontal axis $Y$ in the forward–backward direction. The projection of the centre of the feet pressure on the platform surface was recorded as a dynamic parameter changing its position per unit of time. Statokinesiometric tests were conducted with the eyes open and then with the eyes closed.[14]

The Romberg index was analysed using a stabilometric platform or a double-plate posturograph. The Romberg index is defined as the quotient of the results obtained with the eyes open (EO) and the results obtained with the eyes closed (EC). An obtained Romberg index greater than 1 indicates an increase in the swaying motion of the body, i.e. a lower level of body stability when the eyes are closed. The result obtained is interpreted as a greater impact of the visual stimulus on maintaining a stable posture. On the other hand, a Romberg index of less than 1 represents a decrease in the swaying motion of the body when the eyes are closed and, thus, the result is described as a more stable posture.[15]

The subject was provided with instructions with regard to the procedure for testing using a double-plate posturograph. The coordination test was conducted as follows: the respondent, following a 5-minute rest in a sitting position, would stand on the platform of a double-plane posturograph. The respondent was asked to assume a relaxed standing posture on the platform, with the arms placed along the side of the body. A visual fixation point in the form of a black circle on a white background, divided into four equal parts, is placed on the wall at a height of 1.70 m, at a distance

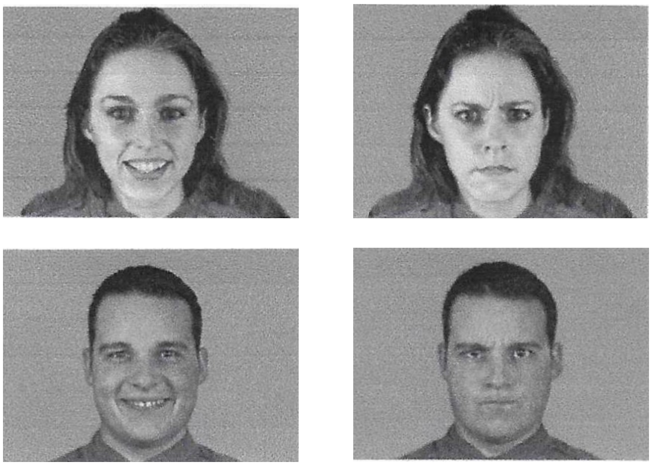

**Figure 1. Photographs from the affective image database Montreal Set of Facial Displays of Emotion (MSFD).[16]**

of 2.20 m from the subject. The subject's task was to focus their gaze on the centre of the circle and maintain a vertical posture on the platform, both under the training conditions for 15 s, and during the 30-s proper test whose results were reflected in the computer program recording. Two measurements were taken in succession: the first one with the subject's eyes open, while the second one in the same posture, with the subject's eyes closed as the control prerequisite of the test.

The next stage of the test using the double-plate posturograph was to verify the eye-hand coordination, i.e. the postural stability in relation to the visual affective stimulus. The test on the platform proceeded in an identical manner according to the above-described procedure, a change was made in relation to the visual fixation point. In place of the circle, an A4-sized black-and-white photograph of an adult person with an affective facial expression showing the emotion of joy or anger was placed. The photographs were sourced from the affective image database Montreal Set of Facial Displays of Emotion (MSFDE), after receiving prior permission to download and use the photographs in the study (Figure 1).

The following measurements were taken: eyes open / eyes closed – gaze fixation on the reference point, control prerequisite of the test, followed by eyes open / eyes closed – gaze fixation on the photograph with an affective stimulus, i.e. the emotion of joy. The second measurement followed the same order of testing as in the first measurements. However, the affective stimulus was replaced with a photograph expressing the emotion of anger. In terms of the facial expressions presented in the photograph, the images were selected randomly.

### 3.2. Statistical method

Statistical analyses were conducted using IBM SPSS Statistics 23 software. This software was also used to conduct the analysis of descriptive statistics with the Kolmogorov-Smirnov test, 3-way analyses of variance in a combined design and the correlation analysis with the *r* Pearson coefficient. The classical threshold $\alpha = 0.05$ was adopted as the significance level. However, the probability results of the test statistics at a level of $p$ more than 0.05 and less than 0.1 were interpreted as significant at the statistical trend level. The basic descriptive statistics of the test variable level were calculated along with the Kolmogorov–Smirnov test verifying the normality of the distribution of these variables. Moreover, a post-hoc analysis was performed and Sidak's tests were conducted.

## 4. RESULTS

The youth population under study is representative, with an average age of 15 years (Table 1). Slightly more subjects (55%) were city dwellers, while 45% lived in a village. As can be seen in Table 2, differences were noted in the test groups in terms of this characteristic: in the group with hearing impairment, city inhabitants were predominant, while in the healthy youth group, people living in a village were predominant.

In order to check whether the Romberg index level is dependent on the type of exposure to emotional stimuli, the test group, the control group, and the subjects' gender, a three-way analysis of variance in a combined design was conducted: three types of exposure – the control prerequisite, positive emotions, negative emotions, as an intra-group variable, and two test groups, i.e. hearing individuals and deaf individuals and two genders: women and men. Table 3 shows the noted descriptive statistics (see Figure 2).

Post-hoc analysis was performed. Sidak's tests were conducted. A statistically significant difference was noted be-

**Table 1. Subjects' age.**

| Group and gender | Age | | | | $\sigma$ |
|---|---|---|---|---|---|
| | $N$ | Mean | Minimum | Maximum | |
| Deaf youth | | | | | |
| man | 33 | 15.0 | 13.0 | 17.0 | 1.2 |
| woman | 27 | 15.3 | 13.0 | 17.0 | 1.4 |
| total | 60 | 15.1 | 13.0 | 17.0 | 1.3 |
| Hearing youth | | | | | |
| man | 30 | 15.1 | 13.0 | 17.0 | 1.1 |
| woman | 30 | 15.0 | 13.0 | 17.0 | 1.2 |
| total | 60 | 15.0 | 13.0 | 17.0 | 1.2 |
| Total | 120 | 15.1 | 13.0 | 17.0 | 1.2 |

Comments: $N$ – number, $\sigma$ – standard deviation in the population.

**Table 2. The origin of subjects in the analysed groups.**

| Origin | | Group | | Total |
|---|---|---|---|---|
| | | Deaf youth | Hearing youth | |
| Village | $N$ | 27 | 15.3 | 13.0 |
| | % | 60 | 15.1 | 13.0 |
| City | $N$ | 30 | 15.1 | 13.0 |
| | % | 30 | 15.0 | 13.0 |
| Total | $N$ | 60 | 15.0 | 13.0 |
| | % | 120 | 15.1 | 13.0 |

**Table 3. Descriptive statistics of test variables.**

| Control variant | | | Positive emotions | | | Negative emotions | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Visual exposure / group / gender | M | SE | Visual exposure / group / gender | M | SE | Visual exposure / group / gender | M | SE | Visual exposure / group / gender | M | SE |
| Deaf youth | | | Deaf youth | | | Deaf youth | | | Deaf youth | | |
| Woman | 0.90 | 0.10 | Woman | 1.13 | 0.10 | Woman | 0.89 | 0.09 | Woman | 0.97 | 0.07 |
| Man | 1.05 | 0.09 | Man | 0.98 | 0.09 | Man | 0.88 | 0.08 | Man | 0.97 | 0.06 |
| Total | 0.98 | 0.07 | Total | 1.05 | 0.06 | Total | 0.88 | 0.06 | Total | 0.97 | 0.04 |
| Hearing youth | | | Hearing youth | | | Hearing youth | | | Hearing youth | | |
| Woman | 1.23 | 0.10 | Woman | 1.10 | 0.09 | Woman | 1.03 | 0.08 | Woman | 1.10 | 0.06 |
| Man | 1.35 | 0.10 | Man | 0.88 | 0.09 | Man | 1.03 | 0.08 | Man | 1.09 | 0.06 |
| Total | 1.29 | 0.07 | Total | 0.99 | 0.06 | Total | 1.03 | 0.06 | Total | 1.11 | 0.04 |
| Total | | | Total | | | Total | | | Total | | |
| Woman | 1.08 | 0.07 | Woman | 1.12 | 0.07 | Woman | 0.96 | 0.06 | Woman | 1.05 | 0.04 |
| Man | 1.19 | 0.07 | Man | 0.93 | 0.06 | Man | 0.95 | 0.06 | Man | 1.03 | 0.04 |
| Total | 1.14 | 0.49 | Total | 1.02 | 0.45 | Total | 0.96 | 0.42 | | | |

Comments: A statistically significant main effect of the exposure type was noted; $F(2.232) = 4.63$; $P = 0.011$; $\eta^2 = 0.038$; $F$ – variance analysis result; $\eta^2$ – effect strength measure.

tween the control prerequisite verifying the visual fixation on the reference point and the exposure to a negative emotion ($p = 0.009$). Higher results were noted in the control group of hearing youth. The results in the positive exposure variant did not differ from both remaining variants even at the statistical trend level. Therefore, visual exposure to a positive emotion does not contribute to a change in body stability in deaf youth, as compared to hearing youth.

## 5. DISCUSSION

The study noted a different pattern of body stability between the control prerequisite verifying the visual fixation on the reference point and the exposure to a negative emotion. Higher results were noted in the control group of hearing youth.

There is a different cognitive pattern of the reception and interpretation of negative and positive emotions.[17] Difficult events linked to the activation of negative emotions are more significant to humans than positive events.[5–7] Negative affect knocks the cognitive system out from so-called stability, and makes it respond automatically from the nervous system. The cognitive system is forced to generate more intense resources to return to the state of homeostasis, more so than for positive emotions.[7,18] Thomas (2007)[19] pointed out that the ability to recognise facial emotional expressions develops with age, especially as regards the ability to identify negative emotions. The author emphasised the underdeveloped neuronal basis in children and youth. This was confirmed by studies conducted by e.g., Casey (2008)[20], Otağ (2014)[21]. Who obtained results indicating the significant growth of the prefrontal cortex, grey matter in the dorsolateral region and that the amygdala is also subject to development. Development is particularly intensified between 7.5 and 18.5 years of age.

Thomas (2007)[19], however, noted no significant differences in the sensitivity of facial expression recognition among the test groups of healthy children and youth. The authors of the mentioned study attributed this relationship to the myelination development within the neural networks responsible for emotions in the prefrontal-limbic area.[22]

Myelination deficits occur in deaf individuals during the childhood stage, which translates into auditory system development. An imaging-based study on individuals with congenital deafness proved that hearing deprivation is related to myelin deficit in the auditory cortex and the underlying white matter ducts.[22] Brain measurements, conducted in deaf-mute adults using volumetric MRI, demonstrated a decreased white matter-to-grey matter ratio in the Heschl's convolution and the superior temporal gyrus, as compared to the reference group of adults with no hearing impairment.[23] Therefore, the emotional and cognitive development of deaf children and deaf adults is determined by multiple anatomic and physiological aspects.[24]

Another result reflects visual exposure to a positive emotion, which does not contribute to a change in body stability in deaf youth, as compared to hearing youth. Therefore, an adaptive role of positive affect exists, and it is thus reflected

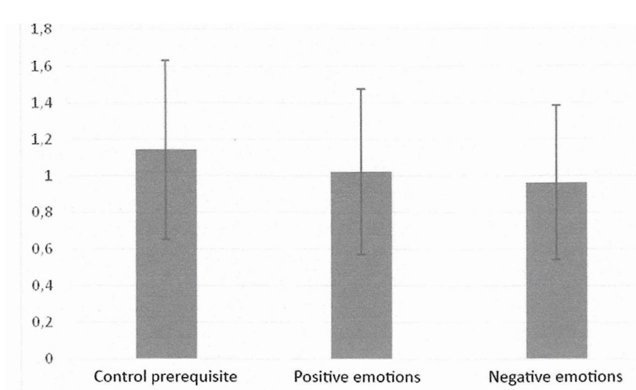


**Figure 2. Romberg's index value depending on the exposure type.**

in a biological reaction that does not disturb the homeostasis of the body. Emotional reactions that are realised become a subset of affective responses.[5,6] The result obtained refers to a study by Garay (2007)[25] conducted in a group of deaf children of hearing parents. It was proven that these children had poorer regulation of their own emotions, a lower level of understanding emotions as compared to the group of hearing children in tasks requiring matching emotions to characters of a story.[25]

Multimodality, thanks to which the nervous system collects information from the environment in the absence of a single modality, activates compensatory resources aimed at generating a system that will provide continuity for further optimal development.[26,27]

## 6. CONCLUSIONS

(1) In the group of deaf youth, there is a different cognitive pattern (of reception and interpretation of negative and positive emotions). Deaf youth need to be provided with continuous rehabilitation in order to obtain the best possible compensatory abilities of the vestibular system.
(2) The visual exposure of positive emotions should be taken into account in the course of rehabilitation stimulation in order to obtain more favorable activity in conditions requiring silencing the senses.
(3) In the course of subsequent studies, it is worth considering the inclusion of multimodal stimuli, especially for deaf youth, taking into account static and dynamic affective stimuli.

### Conflict of interest

The authors declare to have no competing interests.

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### Ethics

Parents provided written informed consent on behalf of their children for diagnosis and medical treatment.
The presented research is part of Kamila Julia Regin's doctoral dissertation, which was approved by the Ethics Committee.

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