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# RELATIONSHIP BETWEEN EMOTIONS AND SOME ASPECTS OF RESPIRATORY ACTIVITY: MORPHOLOGY OF THE CHEST, CYCLIC ACTIVITY, AND ACID-BASE BALANCE[1]

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*Summary*.—The relationship between the style of affective-emotional management measured on the Gottschalk test and respiratory activity of 19 undergraduate students in psychology was examined. The biological measurements were tonic-static attitudes of the chest (morphology), amplitude and duration of the phases of the respiratory activity, and acid-base balance. Statistically significant correlations were observed between affectivity (hostility and anxiety) and some biological scores. A psychophysiological model integrating biological and psychological levels was discussed.

The aim of the present research was to investigate the relationship between affective-emotional behaviors and respiratory activity. For respiration we considered the morphology of the chest (related to the tonic-static activity), respiratory activity (amplitude and duration of the phases of respiration: inspiration, plateau, and expiration), acid-base balance and blood pH.

Psychophysiological research showed evident modifications of respiratory activity during cognitive and emotional processes. Novel stimuli and stimuli of low intensity produce an orienting response (Sokolov, 1963) and a reduction in respiratory activity (Barry, 1982). However, Petelina (1965; see Porges & Raskin, 1981) showed that in the orienting response an initial respiratory pause is followed by reduction in amplitude and frequency of respiration. Walter and Porges (1976) and Porges and Raskin (1969) noted that stimuli of low intensity increase frequency and reduce amplitude of respiratory activity. Stimuli of high intensity produce a defensive response (Sokolov, 1963). Lynn (1966) observed an increase in amplitude and decrease in frequency. Other authors (Ursin & Kaada, 1960; Obrist, *et al.*, 1969) examined bradycardia and inhibition of respiratory activity during anticipatory phase of a response to aversive stimuli.

Svebak and Dahlen (1981) observed tonic changes in somatic and autonomic activity in task sequence of relatively long duration and increased difficulty of task. In particular, tonic modifications of the intercostal muscle activity, which increased during the sequence of exercises in relation to the difficulty of the task, were observed. The elevated myographic activity scores produced a slow "but tonic" increase of the diameters of the chest.

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Phasic modifications of frequency and amplitude of respiration were also observed. Neurophysiological research on the cat (Bonvallet & Bobo, 1972) showed that the stimulation at different points of the hypothalamus and of the amygdala produces 18 different respiratory patterns (with increase or reduction of pulmonary ventilation). The most interesting result was a "biphasic respiratory response" provoked by the stimulation of basolateral nucleus of the amygdala. An initial arrest of respiration was followed by an increase in frequency. This biphasic respiratory behavior was interpreted as an autonomic component of an integrated biphasic response, a first phase of alarm reaction followed by flight-fight behavior.

While the stimulation of the basolateral area of the amygdala produced a delayed biphasic response, stimulation of the same hypothalamic area with stimuli of different intensities caused an alarm reaction (for stimuli of lower intensity) or a flight-fight response for stronger stimuli (Ursin & Kaada, 1960; Abraham & Zbrozyna, 1960).

All the research emphasized that the modifications of the respiratory activity are part of an integrated emotional response (hostile behavior). We think a biphasic reaction of the "defense patterns" (alarm response with respiratory arrest and flight-fight behavior with an increased respiratory frequency) can phasically occur in response to external or internal stimuli.

It is also possible that the alarm reaction persists without overt behavior (flight-fight) appearing. So from a clinical point of view, we hypothesize that the mode of respiratory regulation is modulated by the emotional state. In other words, we hypothesized that internal, psychodynamically relevant hostile stimuli produce chronic modifications of respiratory activity as well as some static morphological change of the chest. We hypothesized also that the modifications persist for the duration in which the internal stimuli are present. Then the chronic modification of respiratory activity leads to modifications of the acid-base balance of blood. In fact, a pulmonary hyperventilation produces alkalosis and hypoventilation acidosis. We expect slight displacements of the acid-base balance and of the blood pH to appear in normal subjects in relation to their style of management of emotions.

In this paper we have studied the relationship among style of management of emotions, structure of the chest, duration and amplitude of the respiratory phases (inspiration, plateau, and expiration) registered from different points of the chest, and acid-base balance. The style of management of emotions is indicated by an analysis of verbal content as proposed by Gottschalk (1969).

## METHOD

### *Subjects*

The experimental group included a total of 19 men and women who were undergraduate students in psychology. They were between 19 and 31 yr. old.

*Measures*

The static measures of the thorax were carried out using anthropometric calipers. We calculated the expansion of the high anterior area, the lower fore-back expansion, and the transversal lower expansion of the chest.

The chest has at rest different levels of expansion. In other words the cyclic phasic activity of respiration takes place on chests which have different levels of expansion at rest (i.e., during postexpiration phase). For us the degree of expansion of the high anterior area of the chest is indicated by the reciprocal spatial positions of the angulus sterni and the humeral apophysis. It is possible that the angulus sterni and the anterior face of the humeral apophysis may both be on the same frontal plane or that the frontal plane passing through the angulus sterni is before or behind the frontal plane passing through the anterior surface of the shoulders. We assume that in a relatively more expanded chest the position of the angulus sterni would be prominent with respect to the humeral apophysis, i.e., the chest is relatively leaning out with respect to the shoulders. To quantify this aspect of the protrusion of the chest we have calculated the distance between the plane passing through the angulus sterni and humeral apophysis. The distance is zero if the two structures are on the same plane or has a positive or negative value if the angulus sterni is respectively before or behind the humeral apophysis. The distance between sternum and shoulder is calculated as the difference of the distance (in cm) between each of those two points of the body and an external structure placed in front of the subject (in a frontal parallel plane).

Such fixed structure is composed by two crossed mobile rods (one vertical and one transversal). The transversal one is placed in a frontal plane parallel to the anterior area of the body; it can move vertically and assume two different positions, parallel to the angle of Louis (a) and parallel to the anterior surface of the humeral apophysis (b). From each of the two positions to other horizontal mobile rods, perpendicular to the transversal one, reaches respectively the angulus sterni (Louis) and the humeral apophysis. The degree of protrusion is calculated as the algebraic difference of the distance from position a of the transversal rod to the angle of Louis minus the distance from position b of transversal rod to the humeral apophysis (anterior surface).

The lower fore-back expansion of the chest was calculated as the difference between the measured distance between the xiphoid apophysis and the corresponding point of the vertebral column which is of the same horizontal plane minus the measure of the distance between the angle of Louis and the corresponding point of the vertebral column. The transversal lower expansion of the chest was indicated by difference in the distance between the last ribs, measured by an anthropometric compass at the level of the "linea axillaris intermedia" (longitudinal line descending from the armpit), minus the distance between the two armpits; the measurement was made on the lateral side of the chest corresponding to the middle "linea" of the armpits. The above-mentioned measurements were made with the subjects standing normally without support.

Respiratory activity at rest was measured by a photoelectric cell apparatus connected to a 3-channel recorder. The photoelectric cell was placed at the distance of 3 cm from the skin surface of the chest of a supine subject at the level of angulus sterni and at the level of the xiphoid apophysis.

From the graphically recorded activity we calculated: (1) the amplitude of inspiration as the distance (in mm.) between the isoelectric line and the point placed at the end of ascending deflection of inspiration phase, (2) the amplitude of expiration as the distance between the onset of the deflection of the expiration phase and the isoelectric line, (3) the duration (in sec.) of inspiration phase, (4) the duration of the expiration phase, and (5) the duration of the phase of plateau. Each subject lay on a medical-type cot in a laboratory room which was kept at 26° C. Respiratory activity was recorded for 3 min. For each variable a mean value of the last minute was calculated (amplitude of inspiration, etc.).

The acid-base balance of the blood was measured by a Radiometer E 33 BS which determines pH, $pCO_2$, $pO_2$, and $HCO_3$ standard. A blood sample was taken from the cubital artery from a seated subject between 10:30 a.m. and 11:30 a.m., two hours after breakfast.

The study of modulation of emotional behavior was carried out using Gottschalk's method (1969). The content analysis identifies three forms of hostility: (a) directed outward both overt (from the subject to others) and covert (attributed to others); (b) directed inward, that is, from the subject on to himself; and (c) ambivalent, that is, hostile attitudes from other people toward the self of the interviewed subject. Moreover, the Gottschalk test includes a measure of anxiety. The subject was asked to talk for 3 min. about an interesting or dramatic experience of his life. A recording of this verbal behavior was made. This material was then analyzed by two independent judges using the method of content analysis of verbal behavior described by Gottschalk (1969), who calculated the magnitude of an affect using the formula, $\sqrt{100 \times (f_1w_1 + f_2w_2 \ldots f_nw_n + 0.5)}/N$.

The measurements were made in a laboratory room of an hospital of Rome and were carried out in the morning on different days.

## Results

The final scores for each subject on the Gottschalk test were the mean values of the two independent judges' scores which were highly correlated (from 0.89 to 0.95).

The mean values and the standard deviations of the examined variables are shown in Table 1. Between the Gottschalk's scores and the chest's static measurements there were the following statistically significant Pearson's corre-

TABLE 1

MEANS AND STANDARD DEVIATIONS OF MEASURES

| Measures | *M* | *SD* |
|---|---|---|
| Respiratory activity measured at the angle of Louis of the thorax | | |
| Inspiration amplitude, mm | 21.9 | 13.16 |
| Expiration amplitude, mm | 21.43 | 13.30 |
| Duration of plateau, sec. | .98 | .37 |
| Inspiration duration, sec. | 1.18 | .34 |
| Expiration duration, sec. | 1.05 | .27 |
| Inspiration/expiration duration ratio, sec. | 1.17 | .28 |
| Respiratory activity measured at xiphoid apophysis | | |
| Inspiration amplitude, mm | 30.27 | 10.16 |
| Expiration amplitude, mm | 30.42 | 8.58 |
| Duration of plateau, sec. | .90 | .40 |
| Inspiration duration, sec. | 1.09 | .31 |
| Expiration duration, sec. | 1.06 | .45 |
| Acid-base balance score | | |
| Hb | 13.40 | 1.79 |
| pH | 7.40 | 0.01 |
| $pCO_2$ | 38.83 | 3.54 |
| $pO_2$ | 100.38 | 7.38 |
| $HCO_3$ | 23.39 | 2.06 |
| Gottschalk scores* | | |
| Anxiety | 1.98 | 0.82 |
| Overt outward hostility | 0.68 | 0.60 |
| Covert outward hostility | 0.60 | 0.60 |
| Total outward hostility | 1.05 | 0.56 |
| Inward hostility | 1.30 | 0.82 |
| Ambivalent hostility | 0.56 | 0.69 |
| Total hostility | 2.91 | 1.26 |
| Expansion of the chest (high anterior area), cm | 5.35 | 2.01 |

*See text for units of measurement.

lations: the overt outward hostility and the total outward hostility are positively correlated with the extent of expansion of the high anterior part of the thorax (protrusion). Respectively, Pearson's correlation for the outward overt hostility was $r = 0.55$; for the total external hostility, $r = 0.52$ ($df$ 17, $p < 0.05$). The tendency to expand the high anterior part of the chest increases in parallel with the level of hostility towards the environment. No statistically significant correlations appear between affectivity and other static measurements of the chest.

For the relationship between affectivity and respiratory activity (amplitude and duration), we made several observations. At the high anterior part of the chest, the duration of inspiration is significantly and negatively correlated with hostility (total outward, ambivalent, and total) and with anxiety, respectively,

$r = -0.40$ and $-0.58$, $-0.44$ and $-0.43$ ($df = 17$, $p < 0.05$). With the ratio of the duration of inspiration/duration of expiration, there were negative, statistically significant correlations with overt outward hostility ($r = -0.60$), total outward ($r = -0.68$), total ($r = -0.48$), and ambivalent hostility ($r = 0.42$, $p < 0.05$, $df = 17$). These results indicate a negative association of hostility with duration of inspiration.

At the xiphoid apophysis, there was a different relationship between affectivity and respiratory changes. Anxiety and inward hostility scores were positively correlated with the amplitude of inspiration ($r = 0.46$ and 0.40, respectively, $df = 17$, $p < 0.05$), while amplitude of expiration was negatively correlated with ambivalent hostility ($r = -0.46$, $df = 17$, $p < 0.05$). The most important correlations are those with amplitude. Between affectivity scores and acid-base balance scores, we noted no significant correlation between Gottschalk's score and pH of the blood, positive, statistically significant Pearson's correlations between covert outward hostility and $pCO_2$ and $HCO_3$: respectively, $r = 0.46$ and 0.39 ($df = 17$, $p < 0.05$) and a negative, statistically significant correlation between total outward hostility and $pO_2$ ($r = -0.39$, $p < 0.05$, $df = 17$).

*Conclusions*

We hypothesized, on the basis of the psychophysiological literature that individual differences in the tonic-static components of the chest (thoracic amplitudes, etc.) were related to the style of management of emotions. Our results indicate a positive correlation between the level of hostility (total and manifest) and the extent of expansion of the high part of the chest at Louis' angle. We interpret the expansion of the chest as a preparatory attitude in flight-fight behavior. The second result indicates an inverse relation between the duration of the inspiratory phase and hostility (total, external total, and ambivalent hostility). When the verbalized hostility increases, the duration of inspiration decreases.

To interpret the data, we consider the research of Bonvallet and Bobo (1972) who demonstrated that the stimulation of one part of the amygdala produces a biphasic respiratory pattern (with arrest of respiration followed by an increase in frequency) which is part of an integrated biphasic behavior: an alarm response followed by flight-fight reaction.

Considering the results we hypothesize that morphological modifications of the thorax caused by the tonic activity of muscles involved in the activity of respiration can be related to the style of management of emotions. We hypothesize that the expansion of the higher anterior part of the thorax is positively correlated with hostility as the protrusion of the chest indicates an inspiratory attitude which is present in the condition of alarm (preparatory phase of the flight/fight behavior). In this case we hypothesize that the subjects assume a chronic attitude of alarm. Then also the respiratory activity measured at the lower anterior part of the thorax (at the xiphoid apophysis) is related to the style of management of emotions: the amplitude of respiration is positively correlated with anxiety and to internal hostility (directed from the subject to himself). The expiratory amplitude is inversely correlated with ambivalent hostility scores (hostile attitude from other people toward the self of the interviewed subject). In other words, we hypothesize that anxiety and internal hostility might enhance the inspiratory amplitude measured at the abdominal level. It is not easy to interpret the biological meaning of the last result because we do not have a neurophysiological model.

In conclusion, we can say that the high anterior part of the chest is involved in expression of an emotional hostile state directed towards the environment and the low anterior part in emotional hostile self-directed behavior and anxiety. Concerning correlations between affectivity and acid-base balance our results showed that the latent hostility has a positive significant correlation with haematic $pCO_2$ and a negative one with haematic $O_2$. Latent hostility may indicate a form of hypercontrol of aggressive intentions. It is possible that such control acts as a level of alveolar-blood exchanges producing also a tendency to reduction of pulmonary ventilation which determines an increase in $pCO_2$ and a decrease in $pO_2$ of the blood.

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