Hyperventilation: a privileged model for the quantitative and qualitative evaluation of the psychophysiological activation with the Trichromatic Theory of Equilibrium of the Vegetative Nervous System

by
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Summary

Hyperventilation is defined as the increased frequency of the respiratory acts in relation to the actual needs of the organism. Hyperventilation causes a significant reduction of the amount of carbon dioxide in the blood. This quantity indicates the central nervous system when to start the respiratory act and how long to prolong. Because of the hyperventilation and the consequent changes in carbon dioxide in circulation, the central nervous system and the vegetative one adapt themselves with several changes. These changes effect also some peripheral physiological parameters (for example skin conductance, heart rate, blood pressure, body temperature, etc.) and may differ from subject to subject. Differences in peripheral response to hyperventilation (or to sequentially hyperventilations) are depending of the previous state of health of the subject, its neurobiological predisposition to respond in a certain way rather than another and to the psychological interpretation of the physiological changes that accompany the hyperventilation. In this work an experiment on an individual case to stimulate reflection on the opportunity of standardization for diagnostic, prognostic and therapeutic purposes is presented, one or more procedures to perform sequential hyperventilation. The author proposes the hyperventilation as a privileged model for the quantitative and qualitative evaluation of the psychophysiological activation using the Trichromatic Theory of Equilibrium of the Vegetative Nervous System and its innovative computerized program to analyze the psychophysiological profile.

Introduction

Respiration is the foundation of our survival. During the respiration oxygen enters the lungs and binds to the haemoglobin present in the red blood cells. The saturation of the haemoglobin in the blood (i.e. haemoglobin filling by oxygen) is about 98%. Through blood circulation, the oxygen carried by haemoglobin, reaches all parts of the body. Each cell in the body uses oxygen as an irreplaceable source of energy and releases the carbon dioxide into the blood. The carbon dioxide passes easily from the blood to the lungs and is then released outside the body in the expiratory phase of the respiration sequence. *Carbon dioxide doesn't represent only a useless product to be eliminated totally*; as a matter of fact, it is normally and consistently present in the blood (in a concentration of about 6%) and its presence is crucial, because it causes the release of oxygen from the haemoglobin. This release enables the next transition of oxygen to the cells. If this transition would be obstructed for a long time, would be highly insufficient or not done properly,

the cells, the tissues and finally the body would be in a state of suffering and danger. The *hypocapnia*, which is the reduction of the concentration of carbon dioxide in the blood, has important physiological consequences, and among them we can mention*: increase of the alkaline reserves*, *vasoconstriction of the cerebral arterioles* and the *bronchi*, *increase of the heart rate*, *reduction of the blood pressure* and of the *peripheral temperature*. Particularly, the temperature decrease is determined by peripheral vasoconstriction, which also aims to compensate the pressure decrease; however, if prolonged in time, vasoconstriction can produce the rebound effect of an excessive pressure increase (hypertension). The hypocapnia may be caused by *the hyperventilation, i.e. from increased frequency of the respiratory acts compared to the actual needs of the organism in that particular situation*. As the haemoglobin saturates at 98%, it has no "space" to carry more oxygen, if not in a irrelevant extend of around 2%. *So hyperventilation is not a way for increasing the oxygen level, rather it is the easiest way to reduce the rate of carbon dioxide, because of its rapid transition from blood to the lungs and from these into the external environment*. The deficit of carbon dioxide in the blood causes difficulties for the central nervous system deciding when to start the respiratory act and how long to prolong it; as a matter of fact, the reduction of carbon dioxide, constitutes information for the brain that leads to a paradoxical decision. As if the brain is saying: there is little carbon dioxide in the blood, so there is more oxygen in the blood than needed, so I do not need to breathe and I will delay breathing. The consequence of this "brain thinking" is that the present oxygen decreases to even lower values. **With the passage of time and remaining in these physiological conditions, the brain enters in alarm, and the central nervous system and the vegetative one adapt themselves with the changes that effect also some peripheral physiological parameters** (for example, skin conductance, heart rate, blood pressure, body temperature, etc.) and may differ from subject to subject. Differences in peripheral response to hyperventilation (or to more sequentially performed hyperventilations) are depending of previous state of health of the subject, its neurobiological predisposition to respond in a certain way rather than another and of the psychological interpretation of the physiological changes that accompany the hyperventilation. So, from the psychophysiological point of view, the hyperventilation is a very interesting problem and could become, developing standardized protocols, a privileged model for the quantitative and qualitative evaluation of the psychophysiological activation for diagnostic, therapeutic and prognostic purposes. The aim of the experiment of the individual case below is to stimulate research in this direction and provide operational information about how to apply, in the field of psycho-physiological evaluation, the Trichromatic Theory of Equilibrium of the Vegetative Nervous System and its innovative computer program.

Subject and Material

For the experiment has been selected a male subject, aged 43, healthy and with a high competence (more than five years experience) regarding the use of relaxation techniques (muscular and visceral) and meditation.

The physiological data were obtained, monitored and saved through an electronic peripheral biofeedback [*PSYCHOLAB VD13,* marked equipment manufactured made by *SATEM S.r.l. at Rome and conform the standards: Safety Standards CEI 62.5 II – Type B, IP (internal power). Directive CEE 89/336/CEE del 23 May 1989 (Radiated Immunity: 100 mV/m in the band of 30 MHz a 1 GHz). Directive CEE 93/42/CEE del 14 June 1993 All.VII – Class I)*].
The biofeedback equipment PSYCHOLAB VD13 was interfaced with a personal computer, with the software PSYCHOLAB P.C. Soft made by SATEM S.r.l. at Rome and with the software of the

Trichromatic Theory of Equilibrium of the Vegetative Nervous System (T.T.E. of VNS), created by Dr. Nunzio Bonaventura and Vincent Viggiano (technician).

All the monitored physiological parameters during the evaluation (for which data were acquired at an average time of 1 datum per second), were those provided by the T.T.E. of VNS (the **GSR**, **HR** and **THE**):

1) *Skin Conductance* (SCL-SCR or **GSR**), detected with two gold surface electrodes (surface 1 cm2) fastened by two velcro straps on the distal phalanges of the forefinger and the middle finger of the dominant hand. The detection method is in µS/cm2 (resolution of 0.01 µS), a constant voltage (0,18 V) and a constant auxiliary power of the patient (limited at 9,3 µA);

2) *Heart rate* (**HR**), detected with three disposable solid gel adhesive surface electrodes for ECG and Biofeedback FOAM - Ag / AgCl [10 S model PG made by FIAB Vicchio SpA (Florence)]. The heart rate was detected by the interval R-R of the ECG signal taken from peripheral derivations (right hand - left hand). The detection range is 20-200 BPM or ms 3000-300, with a resolution of 0.1 BPM. After degreasing the skin with alcohol, the reference electrode was placed in the left wrist, while the two active electrodes were placed respectively in the inner right wrist (green electrode) and the inner left wrist (red electrode);

3) *Peripheral skin temperature* (**THE**), detected by an interchangeable precision sensor (resolution of 0.01 ° C) kept in contact with the surface of the little finger of the non-dominant hand using velcro tape and isolated from external environment interference through a small cotton flock.

Method

During the evaluation of the state and the response of the neurovegetative activation, the subject was made comfortable on a chair with armrests. The room was kept quiet, at a constant temperature (18 ° - 22 °) and humidity up to 50%.

The experiment was performed in one session lasting nearly *15 minutes* (preceded by *10 minutes* of adaptation).

Task was to begin with a brief relaxation and then, on command, perform three hyperventilations. At the end of each hyperventilation followed a visceral relaxation phase defined as "*recovery phase*".

The command to start the first hyperventilation was given after at least 180 seconds after the start of the registration of the profile and after more than 15 seconds from the stabilization of the lowest

value found in parameter **GSR** (this in case of no decrease after 15 seconds from the lowest value detected and at least 180 seconds after the start of the experiment).

The *command to start the recovery phase* was given when the subject, by now tired, stopped hyperventilating or in any case not later than after 30 seconds from the start of hyperventilation.

To define the end of the *recovery phase* were considered the **GSR** and the **HR**.

The *first* and *second recovery* were considered adequate if, after each *hyperventilation*, had passed at least 180 seconds and the values of the **GSR** and the **HR** were reported to values not exceeding 10% of those detected before starting any hyperventilation (for example: value obtained before hyperventilation = 100; calculated value to consider the recovery adequately <110). The *command to finish registration of the profile* would be given if the *third recovery* was considered adequate, that is when, after the third hyperventilation, had passed at least 180 seconds and the values of the **GSR** and the **HR** were reported to values at least 5% less than those measured before the start of the third hyperventilation (for example: obtained value before hyperventilation = 100; calculated value to consider the recovery adequately <95).

The registration of the physiological data was performed in 7 phases (not including the phase of Adaptation):

0) *Adaptation (10 minutes).* During this phase the electrodes were placed according to the methods described above. The subject has been necessarily informed that the evaluation would be harmless and not dangerous, that only would be detected biological signals, that he should sit and relax in his most usual way and that as soon as we would start registrating the data, he should not move or speak anymore. Moreover, he was explained that at the right moment he might be asked to hyperventilate and to continue indefinitely until the moment that he would be to tired or would receive a command to stop. After hyperventilation he should have to relax again in his most usual way. The subject was also informed that hyperventilation could cause a brief dizziness or unusual sensations. However, if he would find himself in a state of discomfort in a way that it should be impossible to continue the evaluation, he could stop at any time by lifting the index finger of the non-dominant hand or by asking it verbally;

1) *Initial Relaxation*. Asking the subject to close his eyes and to relax in his most usual way. Immediately after that starts the registration of data;

2) *First Hyperventilation.* When the scheduled criteria to begin the first hyperventilation were satisfied, the subject was given the command to start hyperventilating and to continue until he was tired or received the command to stop;

3) *First recovery*. The subject was asked to breathe regularly, to relax again in his most usual way and to continue until the conditions for passing to the second hyperventilation were satisfied;

4) *Second Hyperventilation.* When the scheduled criteria to start the second hyperventilation were satisfied, the subject was given the command to start hyperventilating and to continue until he was tired or received the command to stop;

5) *Second recovery*. The subject was asked to breathe regularly, to relax again in his most usual way and to continue until the conditions for passing to the third hyperventilation were satisfied;

6) *Third Hyperventilation.* When the scheduled criteria to start the third hyperventilation were satisfied, the subject was given the command to start hyperventilating and to continue until he was tired or received the command to stop;

7) *Third recovery*. The subject was asked to breathe regularly, to relax again in his most usual way and to continue until the scheduled criteria were satisfied completely to declare the session finished.

Results

The data of the three physiological parameters (**GSR**, **HR** and **THE**), obtained with the software PSYCHOLAB P.C. Soft, were further processed with the software of the **Trichromatic Theory of Equilibrium of the Vegetative Nervous System** (T.T.E. of VNS).
The T.T.E. of VNS is a new theory and provides for an innovative method of computerized processing (see the articles: *"The Peripheral Biofeedback and the Trichromatic Theory of Equilibrium of the Vegetative Nervous System" and "The Future of Peripheral Biofeedback: the Trichromatic Theory of Equilibrium of the Vegetative Nervous System*, both published on the website www.ttesystems.eu). This methodology applies the *simultaneous detection and processing* (second per second) of the values of three of the four physiological parameters described above: the **Digital Skin Conductance** (SCL-SCR or **GSR**), the **Heart Rate** (**HR**) and the **Skin Temperature** (**THE**). Through the computerized elaboration of the values of these three parameters, the T.T.E. of VNS allows to observe, analyze, control and then modify in real time the state of equilibrium of Sympathetic and Parasympathetic Section of the Vegetative Nervous System and to draw up an absolutely innovative psychophysiological profile.

In **Pct. 1** the **Combined Profile** of the **GSR**, the **HR** and the **THE** is shown. The values of the three values were made comparable evaluating them on a *Scale 0-1*. For each parameter has been considered its higher value and it was assigned a value of 1. The other values were calculated proportionally to the value of 1.
In the picture is clearly visible the adequacy of the *phase of the initial visceral relaxation*, lasting 196 seconds and is characterized by a relevant decrease of the values of the **GSR** and a significant decrease of the values of the **HR**. Also the trend of the **THE** increases conspicuously, after a initial slight decrease, indicating the occurrence of a significant peripheral vasodilatation

(probably favoured by muscle relaxation that usually accompanies the first early phases of a relaxation exercise).

The *first hyperventilation phase* lasts 26 seconds and is characterized by a sudden and substantial increase of the values of all three parameters (*value of the **GSR** obtained at the start of the hyperventilation = 2,03* µS*; value of the **GSR** obtained at the end of the hyperventilation and at the start of the recovery phase = 4,41* µS*; value of the **HR** obtained at the start of the hyperventilation = 59,60 Bpm; value of the **HR** obtained at the end of the hyperventilation and at the start of the recovery phase = 105,80; value of the **THE** obtained at the start of the hyperventilation = 26,11 C°; value of the **THE** obtained at the end of the hyperventilation and at the start of the recovery phase = 26,98 C°).*

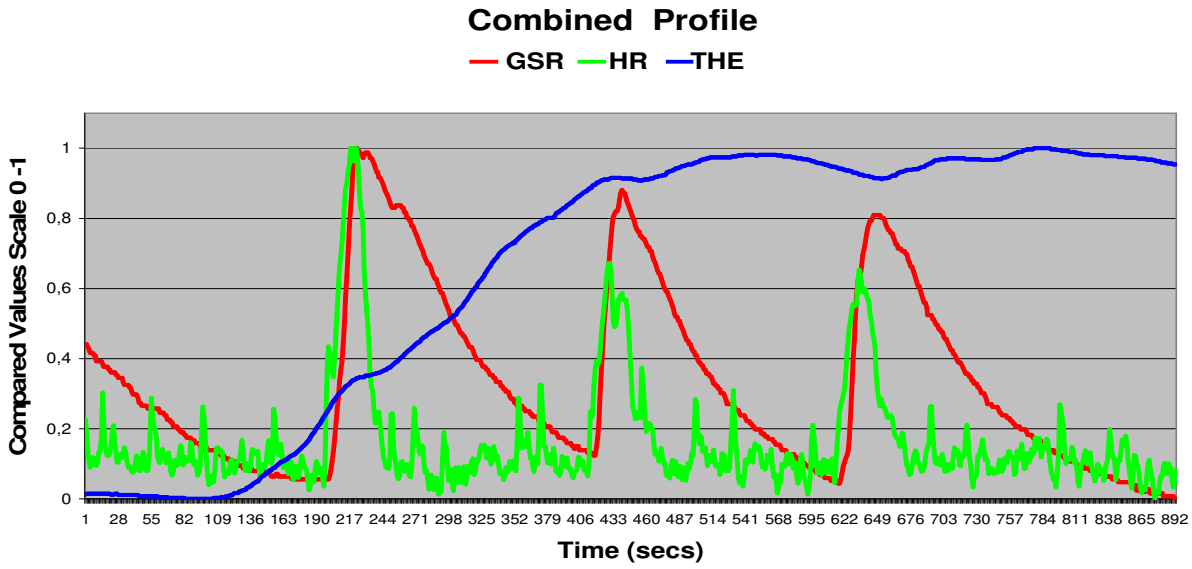
After the first hyperventilation starts the *first recovery phase*, that lasts 189 seconds. This phase is characterized by a slow and continuous decrease of the values of the **GSR**, by a quick and considerable decrease of the values of the **HR** and by a continuous and progressive increase of the values of the **THE**. The first recovery phase has continued until the scheduled criteria for passing to the second hyperventilation were satisfied (*value of the **GSR** obtained at the start of the first hyperventilation = 2,03* µS*; calculated value to consider the recovery adequate < 2,23* µS*; value of the **GSR** obtained at the end of the recovery and at the start of the second hyperventilation = 2,22* µS*; value of the **HR** obtained at the start of the first hyperventilation = 59,60 Bpm; calculated value to consider the recovery adequate < 65,56 Bpm; value of the **HR** obtained at the end of the recovery and at the start of the second hyperventilation = 61,00 Bpm*).

The *second hyperventilation phase* lasts 18 seconds and still shows a quick and considerable increase of the values of the **GSR** and of the **HR**, while the values of the **THE** continue to rise, but almost imperceptibly and also showing a slight decrease at the end (*value of the **GSR** obtained at the start of the hyperventilation = 2,22* µS*; value of the **GSR** obtained at the end of the hyperventilation and at the start of the recovery phase = 3,67* µS*; value of the **HR** obtained at the start of the hyperventilation = 61 Bpm; value of the **HR** obtained at the end of the hyperventilation and at the start of the recovery phase = 90,10; value of the **THE** obtained at the start of the hyperventilation = 31,35 C°; value of the **THE** obtained at the end of the hyperventilation and at the start of the recovery phase = 31,61 C°).*

After the second hyperventilation starts the *second recovery phase*, that lasts 181 seconds. Also this phase is characterized by a slow and continuous decrease of the values of the **GSR** and by a quick and considerable decrease of the values of the **HR**. Different than what we have seen during the first recovery the values of the **THE**, after an initial increase, reach a peak and then begin to decrease gradually until the start of the third hyperventilation. The second recovery phase has continued until the scheduled criteria for passing to the third hyperventilation were satisfied (*value of the **GSR** obtained at the start of the second hyperventilation = 2,22* µS*; calculated value to consider the recovery adequate < 2,44* µS*; value of the **GSR** obtained at the end of the recovery and at the start of the third hyperventilation = 2,02* µS*; value of the **HR** obtained at the start of the second hyperventilation = 61,00 Bpm; calculated value to consider the recovery adequate < 67,01 Bpm; ; value of the **HR** obtained at the end of the recovery and at the start of the third hyperventilation = 63,40 Bpm*).

The *third hyperventilation phase* lasts 22 seconds and still shows quick and considerable increase of the values of the **GSR** and the **HR**, while the values of the **THE** present a totally different trend compared to the one we have seen in the two previous hyperventilation phases; as a matter of fact, they keep on decreasing until the end of hyperventilation (*value of the **GSR** obtained at the start of the hyperventilation = 2,02* µS*; value of the **GSR** obtained at the end of the hyperventilation and at the start of the recovery phase = 3,48* µS*; value of the **HR** obtained at the start of the hyperventilation = 63,40 Bpm; value of the **HR** obtained at the end of the hyperventilation and at the start of the recovery phase = 89,20; value of the **THE** obtained at the start of the hyperventilation = 31,89 C°; value of the **THE** obtained at the end of the hyperventilation and at the start of the recovery phase = 31,70 C°).*

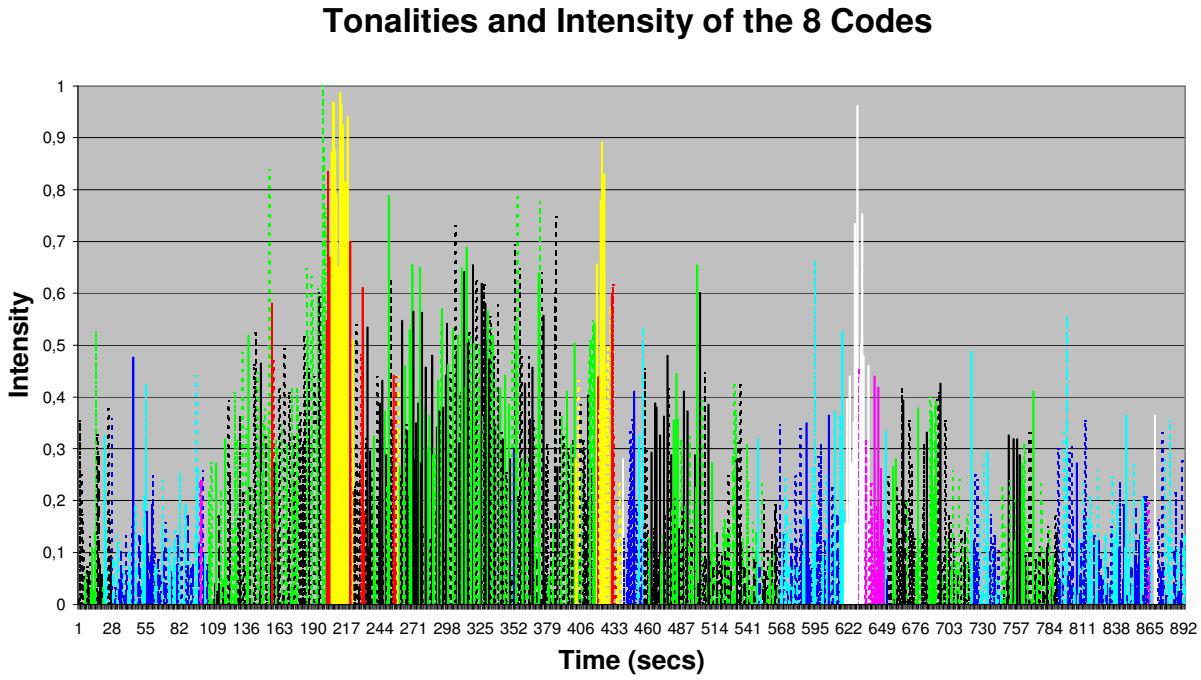
After the third hyperventilation starts the *third recovery phase*, that lasts 258 seconds. Like the two previous recovery phases also this one presents a slow and continuous decrease of the values of the **GSR** and a quick and considerable decrease of the values of the **HR**. As has been ascertained in the second phase of recovery the values of the **THE** after an initial and almost continuous increase, reach a peak and then begin to decrease gradually until the end of the experimental session. Despite this trend the value of the **THE** obtained at the end of the experimental session is anyhow higher than the one obtained at the start of the recovery phase (*value of the **THE** obtained at the start of the recovery phase = 31,70 C°; value of the obtained at the end of the experimental session = 31,94 C°*). The third recovery phase has continued until the scheduled criteria for ending the experimental phase were satisfied (*value of the **GSR** obtained at the start of the third hyperventilation = 2,02* µS*; calculated value to consider the recovery adequate < 1,90* µS*; value of the **GSR** obtained at the end of the experimental session = 1,89* µS*; value of the **HR** obtained at the start of the third hyperventilation = 63,40 Bpm; calculated value to consider the recovery adequate < 60,23 Bpm; value of the **HR** obtained at the end of the experimental session = 60,20 Bpm*).



Pct. 1

In the following pictures the graphic results of the analysis performed with the T.T.E. of VNS on the **Combined Profile** of the **GSR**, the **HR** and the **THE**, shown before, are illustrated (for proper understanding of the material presented it is indispensable, as an introduction, the perusal of the articles mentioned above and available on the website www.ttesystems.eu).

In **Pct. 2** are appreciable the **Tonalities of Color and the Intensity of the 8 Principal Codes**.
The session starts with the *Visceral Relaxation Phase*. The first 20 sec of this phase are characterized by the Colors (Black and Green) and by the Codes (DSW e DFW) typical of the *Visceral Relaxation Type I* (or with peripheral vasodilatation). The profile continues presenting a brief transition to *Visceral Relaxation Type II* (or with peripheral vasoconstriction), marked by the Colors (Blue and Cyan) and by the Codes (DSC e DFC). At last, the phase ends with a significant *Visceral Relaxation Type I*.



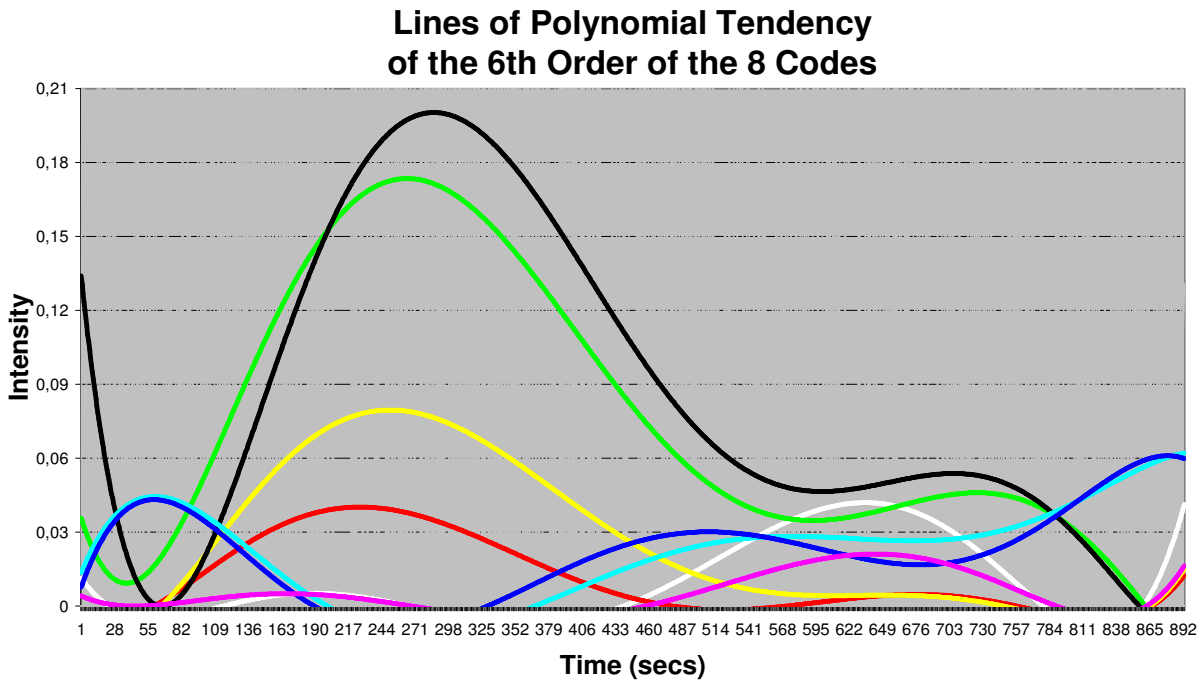
Pct. 2

The *first hyperventilation phase* shows an initial and brief presence of the Color (Red) and the Code (WSW) that characterize the *Anguish by effort for cognitive tasks or physiological control*. The central and final phase of this hyperventilation present the Color (Yellow) and the Code (WFW) that describe *Hyperactivation/Excitement/Nervousness*.
The end of the first hyperventilation starts with the *first recovery phase* with the Color (Red) and the Code (WSW) of the *Anguish by effort for cognitive tasks or physiological control*. This phase

continues and is characterized by per the significant presence of Colors (Black and Greene) and by the Codes (DSW e DFW) typical of the *Visceral Relaxation Type I*.
Different than the first hyperventilation, the *second hyperventilation phase* initially almost doesn't present the Color (Red) and the Code (WSW) that characterize the *Anguish by effort for cognitive tasks or physiological control*. This second hyperventilation starts directly and continues until the end, presenting the Color (Yellow) and the Code (WFW) that describes *Hyperactivation/Excitement/Nervousness*.
The *second recovery phase* starts with a minimum quantity of presence of the Color (Red) and of the Code (WSW) of the *Anguish by effort for cognitive tasks or physiological control*. It then shows a minimum of Color (White) and the Code (WFC) typical of the *Fear/Alarm/Defense* response, to transform quickly into the Colors (Blue an Cyan) and the Codes (DSC e DFC) of the *Visceral Relaxation Type II*. The recovery proceeds with a significant presence of the Colors (Black and Green) and the Codes (DSW e DFW) typical of the *Visceral Relaxation Type I*. In the final part of this recovery phase the Colors (Blue and Cyan) and the Codes (DSC e DFC) of the *Visceral Relaxation Type II* become prevailing.

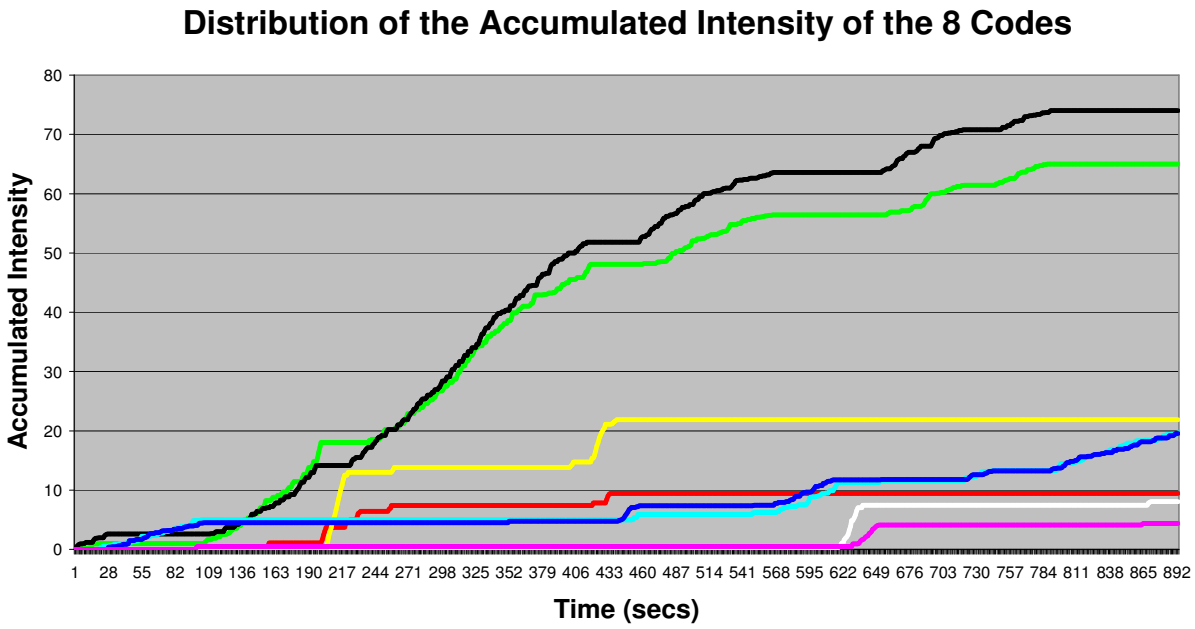
In complete contrast with the other previous hyperventilation phases, the *third hyperventilation phase* doesn't present at all the Color (Red) and the Code (WSW) that characterize the *Anguish by effort for cognitive tasks or physiological control*, neither the Color (Yellow) and the Code (WFW) that indicate *Hyperactivation/Excitement/Nervousness*. But during the whole hyperventilation phase prevail the Color (white) and the Code (WFC) typical for the response *Fear/Alarm/Defense* response.
The *third recovery phase* starts with the brief presence of the Color (Magenta) and of the Code (WSC) that characterize the *Anxious Apprehension* state. The recovery continues with the Colors (Black and Green) and the Codes (DSW e DFW) typical for the *Visceral Relaxation Type I*. Follows a brief period in which there is a *Visceral Relaxation Type II* [Colors (Blue and Cyan) and the Codes (DSC e DFC)], leaving room for another short period of *Visceral Relaxation Type I.* In the final part of this phase and until the end of the session the Colors (Blue and Cyan) and the Codes (DSC e DFC) of the *Visceral Relaxation Type II* prevail again.

Pct. 3 presents the profile of the **Tonality of Color and of the Intensity of the 8 Codes** subjected to a specific processing to evidence the intensity of the **Trend of the 6th Order Polynomial Lines of the 8 Codes.**
This *trend-line* evidences that most of the profile was represented by the Colors (Black and Green) and the traditional Codes (DSW and DFW) of the Visceral Relaxation Type I. Besides in the first part predominates, although to a lesser extent than the *Visceral Relaxation Type I*, the Color (yellow) and the Code (WFW) showing *Hyperactivation/Excitement/Nervousness*. But in the second part the profile is characterized by cold Colors, particularly the Colors (Blue and Cyan) and the Codes (DSC and DFC) of the *Visceral Relaxation Type II*. There is a little presence of the Color (white) and the Code (WFC) typical of the *Fear/Alarm/Defense* response, while a minimum of the Color (Magenta) and the Code (WSC) that characterize the state of *Anxious Apprehension* is detected.



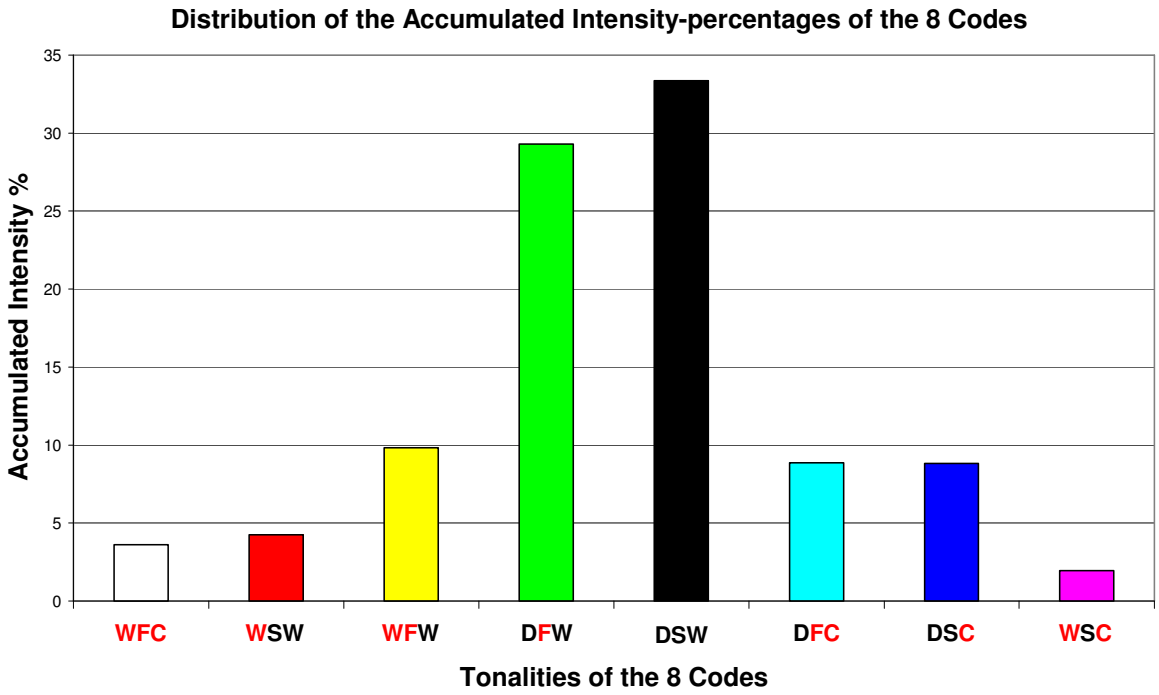
Pct. 3

Pct. 4 shows the **Distribution of the Accumulated Intensity of the 8 Codes**, a reading of the **Combined Profile** of the **GSR**, the **HR** and the **THE** that evidences the trends of the cumulative intensity of the 8 Codes in time. From the graph is clearly detectable that, especially in the first advanced part of the profile, the trends of the Colors (Black and Green) and the traditional Codes (DSW e DFW) of the *Visceral Relaxation Type I* are the most represented. The analysis also clearly reveal the three phases of hyperventilation and recovery. Regarding the three phases of hyperventilation, the first two are characterized by the Color (Yellow) and the Code (WFW) that indicate *Hyperactivation/Excitement/Nervousness*, while the last one is distinguished by the Color (White) and the Code (WFC) typical of the *Fear/Alarm/Difense* response. The first two phases of recovery are evidenced by the Color (Red) and the Code (WSW) that indicate *Anguish by effort for cognitive tasks or physiological control*, while the last one is distinguished by the Color (magenta) and the Code (WSC) typical of the *Anxious Apprehension response*.



Pct. 4

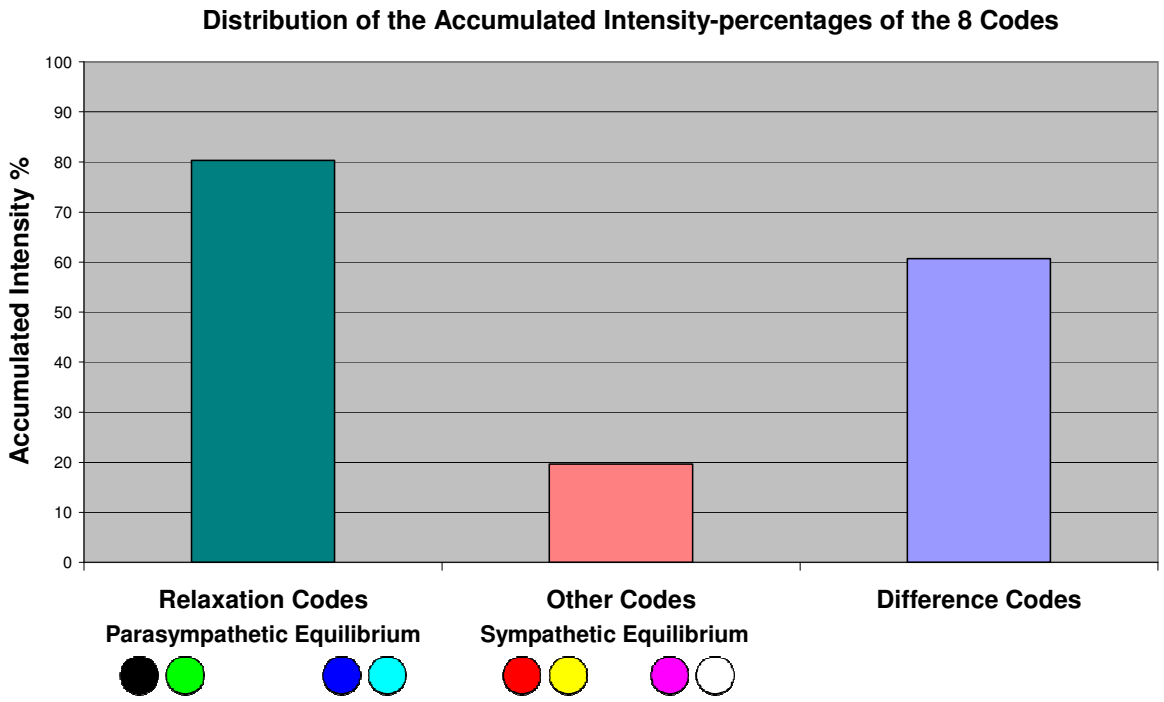
Pct. 5 shows a reading of the **Combined Profile** of the GSR, the HR and the THE using histograms to represent the **Distribution of the Accumulated Intensity-percentages of the 8 Codes.** The graph shows that the histograms representing the Colors (Black and Green) and Codes (DSW and DFW) typical of the *Visceral Relaxation Type I* are those which together reach as much as 62.65% of the total Accumulated Intensity of the 8 Codes. Follows the value of 17.69% obtained with the Colors (Blue and Cyan) and the Codes (DSC e DFC) representing the *Visceral Relaxation Type II*, while 9.84% was achieved only by the Color (Yellow) and the Code (WFW) that indicate *Hyperactivation/Excitement/Nervousness*. The other Colors and Codes do not exceed the value of 5% and together they get 9,82 %.



Pct. 5

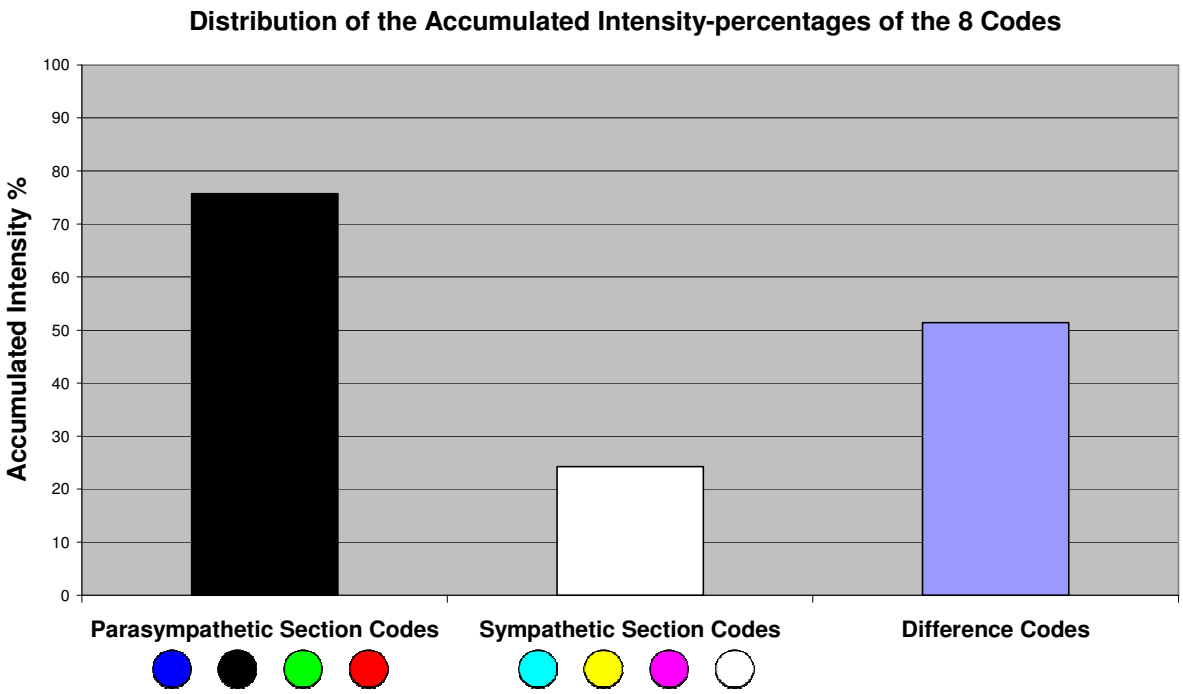
In **Pct. 6** the elaboration of the **Combined Profile** of the **GSR**, the **HR** and the **THE** uses histograms to represent the **Distribution of the Accumulated Intensity-percentages of the 8 Codes** and divides them into *2 categories*: one for the *Visceral Relaxation Type I and II Codes* and one for the other 4 Codes. The *Visceral Relaxation Type I and II Codes* (DSW = Black; DFW = Green; DSC = Blue; DFC = Cyan) are an expression of the Parasympathetic Equilibrium (or of the Sympathetic activity), while the other 4 Codes (WSW = Red; WFW = Yellow; WSC = Magenta; WFC = White) are referred to the Sympathetic Equilibrium.

80,34 % of the total of the Distribution of the Accumulated Intensity-percentages of the 8 Codes was obtained from the *Visceral Relaxation Codes I and II*, while the remaining 19,66 % was realized by the other 4 Codes. The difference between the two categories of Codes is 60.68% in favour of the *Visceral Relaxation I and II Codes*.



Pct. 6

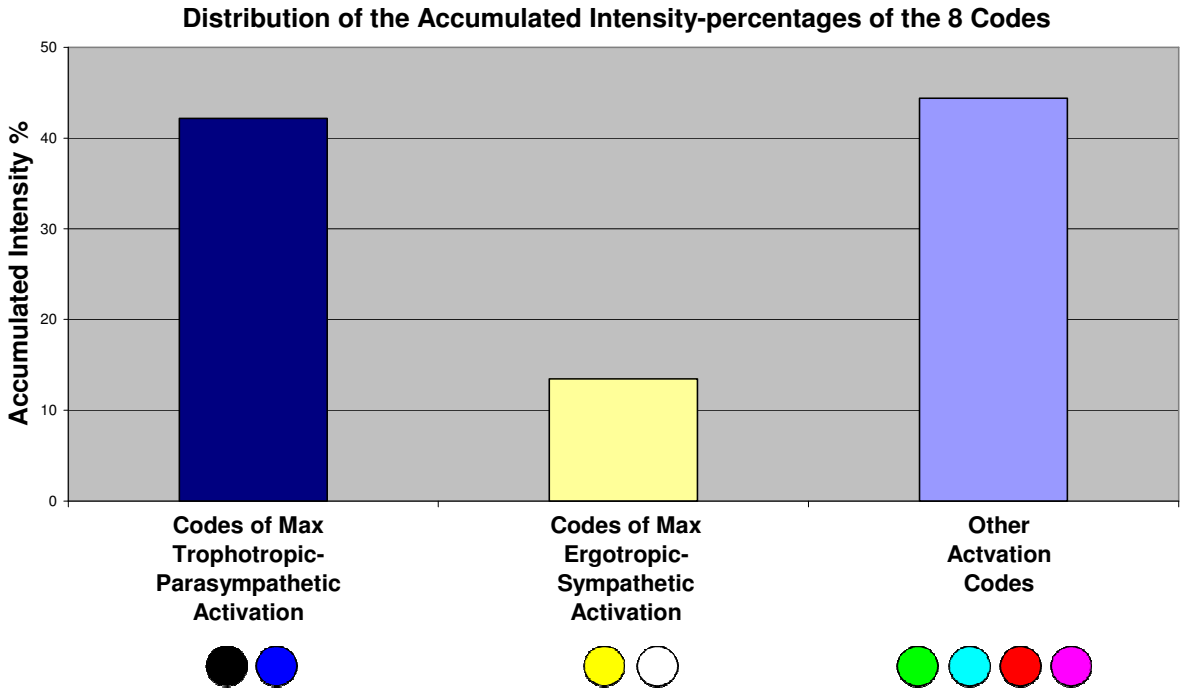
In **Pct. 7** the elaboration of the **Combined Profile** of the **GSR**, of the **HR** and of the **THE** uses histograms to represent the **Distribution of the Accumulated Intensity-percentages of the 8 Codes** and divides them into *2 categories*: one for the *Parasympathetic Section Codes* (or minor *Sympathetic activation*) and one for the *Sympathetic Section Codes*. The *Parasympathetic Section Codes* (DSC = Blue; DSW = Black; DFW = Green; WSW = Red) are those that present maximum one "red letter" (letter that indicates that this parameter is under the complete or partial control of the Sympathetic System), while the other 4 Codes (DFC = Cyan; WFW = Yellow; WSC = Magenta; WFC = White) are those that present two or more "red letters" (indicating a higher prevalence of the parameters that are under complete or partial control of the Sympathetic System). 75,73 % of the total of the Distribution of the Accumulated Intensity-percentages of the 8 Codes was obtained from the *Parasympathetic Section Codes*, while the remaining 24,27% was realized by the *Sympathetic Section Codes*. The difference between the two categories of Codes is 51,46 % in favour of the *Parasympathetic Section Codes.*



Pct. 7

In **Pct. 8** the elaboration of the **Combined Profile** of the GSR, of the HR and of the THE uses histograms to represent the **Distribution of the Accumulated Intensity-percentages of the 8 Codes** and divides them into 3 *categories*: one for the *Maximum Trophotropic-Parasympathetic Activation Codes* (DSW = Black; DSC = Blue) (or minimum Ergotropic-Sympathetic activation); one for the *Maximum Ergotropic-Sympathetic Activation Codes* (WFW = Yellow; WFC = White); and one for all the other 4 Codes left (DFW = Verde; DFC = Celeste; WSW = Rosso; WSC = Magenta).

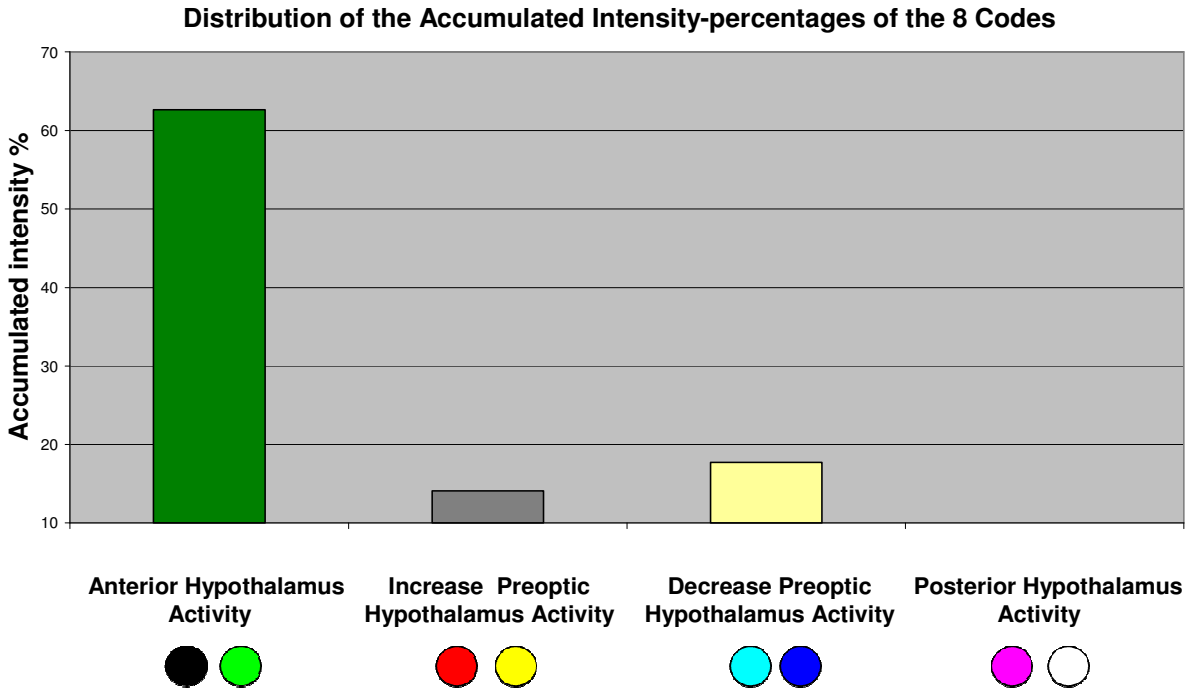
42,17 % of the total of the Distribution of the Accumulated Intensity-percentages of the 8 Codes was obtained from the *Maximum Trophotropic-Parasympathetic Activation Codes*, 13,45 % was realized by *Maximum Ergotropic-Sympathetic Activation Codes*, and the remaining 44,38 % by all the other 4 Codes left.



Pct. 8

In **Pct. 9** the elaboration of the **Combined Profile** of the **GSR**, of the **HR** and of the **THE** uses histograms to represent the **Distribution of the Accumulated Intensity-percentages of the 8 Codes** and divides them into *4 categories*: one for the *Anterior Hypothalamus Activity Codes* (DSW = Black; DFW = Green), one for the *Increase of the Anterior Preoptic Area Codes* (WSW = Red; WFW = Yellow), one for the *Decrease of the Anterior Preoptic Area Codes* (DSC = Blue; DFC = Cyan) and finally the one for the *Posterior Hypothalamus Activity Codes* (WSC = Magenta; WFC = White).

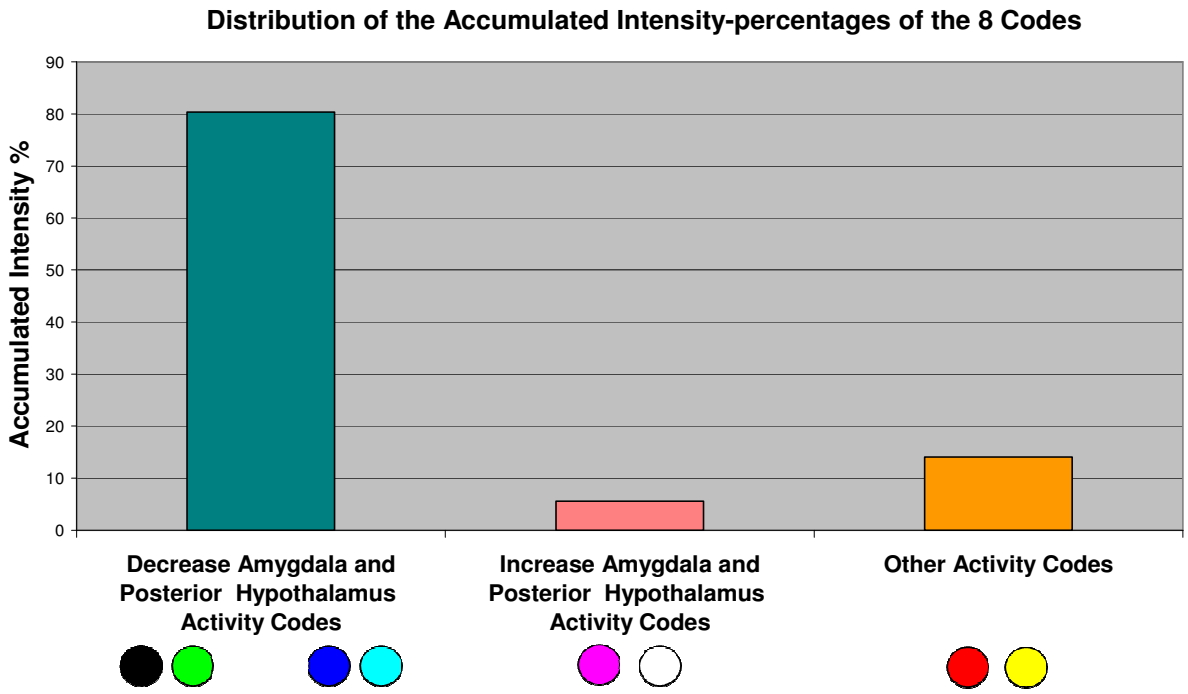
62,65 % of the total of the Distribution of the Accumulated Intensity-percentages of the 8 Codes was obtained from the *Anterior Hypothalamus Activity Codes,* 14,10 % was realized by *Increase of the Anterior Preoptic Area Codes,* 17,69 % was realized by the *Decrease of the Anterior Preoptic Area Codes,* and the remaining 5,56% by the *Posterior Hypothalamus Activity Codes.*



Pct. 9

In **Pct. 10** the elaboration of the **Combined Profile** of the **GSR**, of the **HR** and of the **THE** uses histograms to represent the **Distribution of the Accumulated Intensity-percentages of the 8 Codes** and divides them into 3 *categories*: one for the *Decrease of the Amygdala and the Posterior Hypothalamus Activity Codes* (DSW = Black; DFW = Green; DSC = Blue; DFC = Cyan), one for the *Increase of the Amygdala and the Posterior Hypothalamus Activity Codes* (WSC = Magenta; WFC = White) and finally the one for the activity of the other 2 Codes left (WSW = Red, WFW = Yellow).

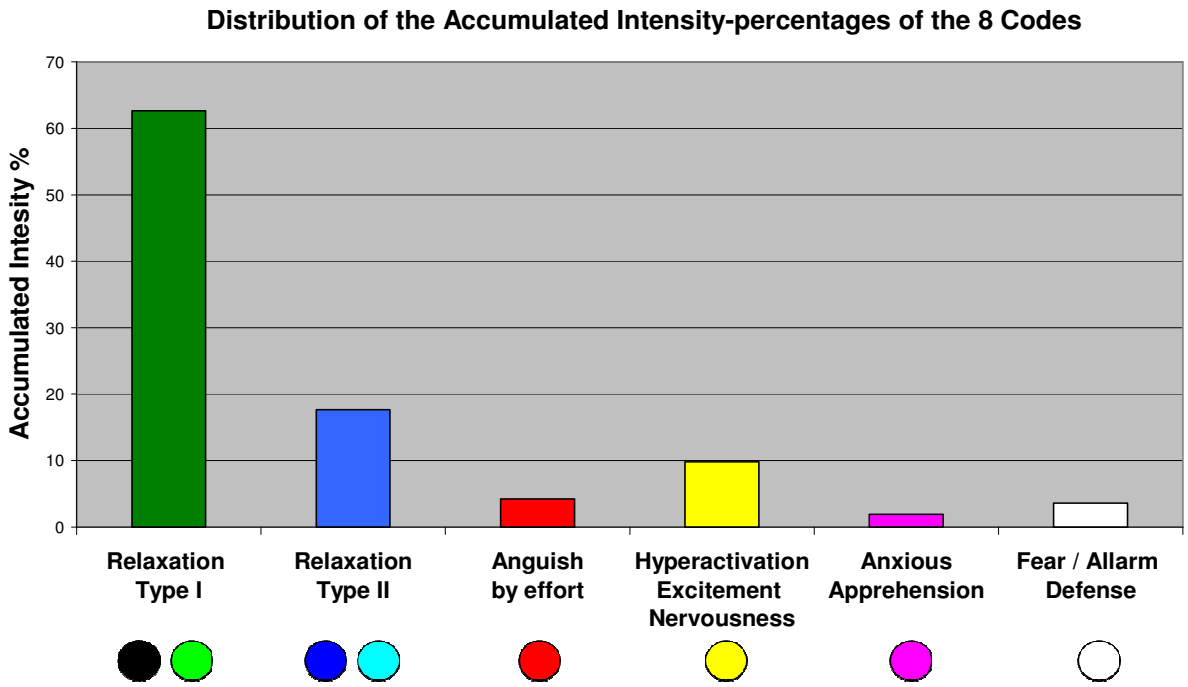
80,34 % of the total of the Distribution of the Accumulated Intensity-percentages of the 8 Codes was obtained from the *Decrease of the Amygdala and the Posterior Hypothalamus Activity Codes*, 5,56 % by the *Increase of the Amygdala and the Posterior Hypothalamus Activity Codes*, while the remaining 14,10 % was realized by the activity of the other 2 Codes left.



Pct. 10

In **Pct. 11** the elaboration of the **Combined Profile** of the **GSR**, of the **HR** and of the **THE** uses histograms to represent the **Distribution of the Accumulated Intensity-percentages of the 8 Codes** and divides them into 6 *categories*: those regarding the ***emotional states related*** **to the physiological responses corresponding to the 8 Principle Codes.** The 6 categories are as follows: *Visceral Relaxation Type I* (DSW = Black; DFW = Green), *Visceral Relaxation Type II* (DSC = Blue; DFC = Cyan), *Anguish by effort for cognitive tasks or physiological control* (WSW = Red), *Hyperactivation/Excitement/Nervousness* (WFW = Yellow), *Anxious Apprehension* (WSC = Magenta) and finally *Fear/Alarm/Defense* (WFC = White).

62,65 % of the total of the Distribution of the Accumulated Intensity-percentages of the 8 Codes was obtained from the *Visceral Relaxation Type I Codes*, 17,69 % was realized by the *Visceral Relaxation Type II Codes*, 4,26 % by the *Anguish by effort for cognitive tasks or physiological control Codes*, 9,84 % by the *Hyperactivation/Excitement/Nervousness Codes*, 1,95 % by the *Anxious Apprehension Codes* and finally 3,61 % by the *Fear/Alarm/Defense Codes*.



Pct. 11

Discussion

The characteristics of the presented psychophysiological profile inspire to a lot of considerations as well concerning the hyperventilation as a privileged model for the quantitative and qualitative evaluation of the activation, as the way to apply the Trichromatic Theory of Equilibrium of the Vegetative Nervous System and its innovative computerized program, in the field of psychophysiological evaluation.

From many points of view the clinical characteristics of hyperventilation are similar to the psychophysiological symptoms that occur in ***Panic Disorder***. The sense of lack of air and/or suffocation, increased heart rate, significant changes in blood pressure, increased sweating, rapid changes in temperature (at an initially substantial overheating generally follows a significant peripheral cooling), feelings of variations in the peripheral sensitivity (tingling in hands, feet or other parts of the body), the sense of mental confusion, feelings of derealization and depersonalization, dizzyness, trembling, high initial muscle tension and the following fatigue (with a possible decrease in muscle tone and the presence until feel fainting) are some of the symptoms that characterize a panic attack. This multiple symptomatology can be increased by the hyperventilation, because the subject, alarmed by the perception of these unusual physiological sensations, prolongs the hyperventilation and contributes actively to a considerable increase of the symptoms. Using the popular technique of breathing into a paper bag and re-breathing the air filled with carbon dioxide remained inside, the subject re-raises the concentration of carbon dioxide in the blood. This practice has as a direct consequence to "stimulate" the brain and to start

breathing, and the appropriate level of oxygen is gradually restored. What's more, breathing becomes slower and deeper, lowering the levels of arousal and reducing the state of mental excitement. Although not so intense and generalized as in a panic attack, during one or more sequentially performed hyperventilations, it's possible that some symptoms, similar to those listed above, are experienced. As explained in detail in the introduction to this article, hyperventilation produces a reduction of the carbon dioxide concentration in the blood (*hypocapnia*) and engraves negatively on the release of oxygen from haemoglobin. If time would be prolonged this effect would not allow the proper use of oxygen by the cells, also making suffer the tissues and the entire organism. **Staying in these physiological conditions, the brain enters into alarm and the central nervous system and the vegetative one adapt themselves with changes, that have repercussions also on the physiological peripheral parameters considered by the T.T.E. of VNS** (**GSR**, **HR** and **THE**).
To study the typology of changes at peripheral level in a normal ideal subject [i.e. to determine what should be the ideal psychophysiological profile of a normal subject, having the competence (natural or acquired) to easily recover from a succession of hyperventilations], was chosen to use a person in good health and with high competence (more than five years of experience) regarding the use of relaxation techniques (muscular and visceral) and meditation. Although the one presented refers only to a single case, more previous unpublished experiments allow to make interesting conclusions about the ideal psychophysiological profile of three sequentially hyperventilations.

Referring to **Tonality of Color** and **Intensity of the 8 Principal Codes** (**Pct. 2** the analysis of the results of this experiment allow us to draw the following conclusions:

1) after the *adaptation phase*, the profile starts (and should continue) with the Colors (Black and Green) and the Codes (DSW and DFW) typical of the *Visceral Relaxation Type I* (or with peripheral vasodilatation). **The quick initial transition to the *Visceral Relaxation Type II*** (DSC = Blue; DFC = Cyan), **or relaxation with peripheral vasoconstriction, probably depends of two main conditions:**
   a) the subject has much experience in practicing relaxation techniques and / or meditation and therefore glides easily and quickly (perhaps partially already in the adaptation phase) into the visceral relaxation typically present during dreamless sleep or normally observed when passed about twenty/thirty minutes from the start of a relaxation exercise (i.e. the elapsed time needed to use up, completely or partially, the *Visceral Relaxation Type I* phase);
   b) the subject has entered, even if only partially, in a defensive phase, only corrupted by the premature peripheral vasoconstriction. Even though the subject has much experience in visceral relaxation experience, he could have started with a partly defensive attitude.
   The presence of colors and codes other than those that have just been considered is also possible. Their presence may depend on many of the same causes that will be considered in the subsequent phases and, therefore, their explanation can be found in them.

2) the *initial phase of the first hyperventilation* shows a certain quantity of the Color (Red) and the Code (WSW) characterizing the *Anguish by effort for cognitive tasks or physiological control*. This Color and this Code are generally also present during the *central phase* of cognitive performance or physiological control that last in time and that, for this reason, do not provide a "work" that involves a that high consumption of "energy"

as what is used in hyperventilation. The peculiar aspect of this Color and this Code is the tendency to maintain under stress a constant, but a little forced, respiratory rhythm. It is possible that the subject forces itself to this unusual rhythm, to control the **HR** [↓ = prevalence of the letter "**S**" (**S**low heart) in respect to the letter "**F**" (**F**ast heart)], in order to adhere properly to the task. The increase of the **GSR** [(↑) = prevalence of the letter "**W**" (**W**et hands) respected to the letter "**D**" (**D**ry hands)] is indicative of the *work* that is doing the body to perform the task and to maintain control. The increase of the **THE** (↑), proved by the prevailing letter "**W**" (**W**arm hands) respected to the letter "**C**" (**C**old hands), confirms the need to release the *heat* produced by the *work* done for the execution of the task to the outside. In the *initial phase of the first hyperventilation*, the presence of this Color and this Code demonstrate the proper initial effort, of "heating", of the preparation to the boost of the body needed to cope with the central and the final phase of the hyperventilation, the one that asks for the maximum of work and energy. It can be assumed that an initial phase of hyperventilation without these characteristics, but showing the typical ones of the *central and the final phase* [Color (Yellow) and Code (WFW) of the *Hyperactivation/Excitement/Nervousness*], i.e. of a sudden and powerful acceleration, is typical of a body which is already in a state of overheating, always ready to burst. These are generally the characteristics of excited, agitated, nervous and impatient subjects. At the contrary, an excessive prolongation of the presence of the Color Red and the Code WSW, so that it protracts to the *central phase of hyperventilation*, would indicate an incapability of the body to burst, to "take off". This condition could be the one for subjects that are already too tired, exhausted or depressed, that fail to raise the energy needed to carry out full hyperventilation, despite the effort and commitment;

3) the *central and final phase of the first hyperventilation* are characterized by the Color (Yellow) and the Code (WFW) that describe *Hyperactivation/Excitement/Nervousness*. This Code is one of the 2 Codes (together with the Code WFC) of the **Maximum Ergotropic Activation**, or better: it represents perfectly the maximum ergotropic activation; in fact, all three parameters indicate a condition of the body characterized by intense work, large power consumption and high loss of energy, in the form of heat loss in the periphery. This Color and this Code are very much present when the subject still has to invest much energy, otherwise, for example in case of *anorexia nervosa*, they tend to be rarely present. **If in the *central and final phase of the first hyperventilation* this Code should be little (or not) present, we can assume the following causes**:
a) low energy level of the subject, that does have the motivation but not enough strength to support the hyperventilation. In this case we have to face or must expect a return to the Color Red and the Code WSW [typical of *Anguish by effort for cognitive tasks or physiological control*]. In conditions of even lower energy, the upcoming transition to the Colors and Codes typical of the *Visceral Relaxation Type I* (DSW = Black; DFW = Green) and, especially, *Type II* (DSC = Blue; DFC = Cyan) may be the most frequent one;
b) presence of unpleasant physical sensations associated with hyperventilation and possible transition to the Color (Magenta) and the Code (WSC) that characterize the state of

Anxious Apprehension. This color and code show a "slowing down" of the body, a premature deceleration after the effort not yet completed to carry out the total hyperventilation; this type of deceleration indicates a conflict between the motivation to perform the task and the fear to carry it out (*performance anxiety*). The slowing down of the body was performed in a "protective" way, with the "seat belt fastened". In this Code, this condition is detectable by the presence of peripheral vasoconstriction [**THE** (⇓)], that indicates the *defensive state* in which the body, of those subjects that try to sustain a generally quite unpleasant emotional experience, finds itself. Moreover, elsewhere it was explained that the *Anxious Apprehension* can be considered as an inevitable attempt to contain [*limiting the heart activity* ("**S**">"**F**")] a continuous and pathological panic response. This means that hyperventilation could produce a possible answer to *Fear/Alarm/Defense* [transition to the Color (White) and the Code (WFC)].

Finally, in this Code, the increase of the **GSR** (⇑) is indicative for the physiological work needed to contain physical sensations associated with the state of uncertainty or insecurity typical of a defensive protective phase;

c) <u>a condition that preceeds hyperventilation: pre-alarm or excessive psychophysical stress</u>. In this case the Color White and the Code WFC almost certainly tend to appear, indicating the typical response of *Fear/Alarm/Defense*. Probably the physical sensations associated with hyperventilation and the condition of early pre-alarm or psychophysical stress in which the body found itself before starting the hyperventilation have provoked a response characterized by the trend of **maximum activation of the Sympathetic System**:

[**I**ncrease of the **GSR** (⇑), **I**ncrease of the **HR** (⇑), **D**ecrease of the **THE** (⇓)]. Because of the same considerations that will be discussed later on for the Color Yellow and the Code WFW, and some others, this trend can only rarely be sustained for a long time together with other Codes, and even less alone. This Code is one of the two Codes (together with the Code WFC) of **Maximum Ergotropic Activation** and has to be replaced as soon as possible by other Codes;

4) the *initial phase of the first recovery* presents the Color Red and the Code WSW, expression of the understandable "slowing down" of the body, of its deceleration after the effort taken to perform the hyperventilation. However, this is a physiological slowing down fitting to the task, not like the one seen above in the case of the Color (Magenta) and the Code (WSC) that characterize the state of *Anxious Apprehension.*

The absence of this Color and this Code in the *initial phase of the first recovery* may depend on::

a) <u>a sudden slowing down of the body, that does not have the ability to "land" softly, to return gradually to the physiological state prior to the hyperventilation</u>. This may be the condition of those subjects that have little energy or those that tend to consume its own resources too much and too quickly, perhaps even for the high intensity of hyperventilation. These subjects, not knowing properly how to manage its own energy resources, remain without "fuel" to perform a smooth landing. In these cases it is possible that the end of hyperventilation presents the typical profile of the *Visceral Relaxation Type II* (DSC = Blue; DFC = Cyan), that evidences the need of the body to recover a lot as soon as possible. The peripheral vasoconstriction that characterizes this visceral relaxation

establishes the way to contain the energy loss that could be lost as heat. More rarely it may present the profile of the *Visceral Relaxation Type I* (DSW = Black; DFW = Green). In this last case, the subject, even being exhausted, or has resources to waste (evidencable condition of heat loss determined by the peripheral vasodilatation that accompanies this kind of visceral relaxation), or does not even have the energy, or has other difficulties in containing the heat loss through an appropriate peripheral vasoconstriction;
b) by maintaining an almost constant state of excitement, even if in lesser intensity, typical of the *central and final phase of the first hyperventilation* [characterized by the Color (Yellow) and by the Code (WFW) that describe the *Hyperactivation/Excitement/Nervousness*]. This condition, however, cannot last much because the Color Yellow and the Code WFW may occur only in the absence of other Codes (particularly, without the Color Red and the Code WSW) as an expression of *brief but intense stress* (cognitive or physiological). Also in this case, the relation between respiration and heart activity is significant. The frenetic respiratory rhythm typical of hyperventilation causes a ***lack of breath*** (thoracic breathing) and is associated with a significant increase of the **HR** [↑ = prevalence of the letter "**F**" (**F**ast heart) respected to the letter "**S**" (**S**low heart)]. The increase of the **GSR** [(↑) = prevalence of the letter "**W**" (**W**et hands) respected to the letter "**D**" (**D**ry hands)] is indicative of the physiological work associated with the state of excitement. Like for the Code WSW, the increase of the **THE** (↑) is indicative of the need to release the excess of heat to the outside. After a certain time, that varies from subject to subject, the Color Yellow and the Code WFW will inevitably have to be matched by another Code having the letter "**S**" (**S**low heart) respected to the letter "**F**" (**F**ast heart). As an alternative, the subject finds itself in an unbearable physiological state of continuing and growing tachycardia;

5) the *central and final phase of the first recovery* present fully the Colors and Codes of the *Visceral Relaxation Type I* (DSW = Black; DFW = Green), especially the Color Black and the Code DSW; in fact, this Color and Code and describe, together with the Color Blue and the Code DSC, the condition of **Maximum Trophotropic Activation** (of savings or energy recovery). In this case the subject, even being exhausted, has still resources to waste (evidencable condition of heat loss determined by the peripheral vasodilatation that accompanies this kind of visceral relaxation). As an alternative, would be also acceptable the presence of the Colors and Codes (DSC = Blue; DFC = Cyan) of *Visceral Relaxation Type II*. Please note, however, that at this stage of recovery, the significant presence of the *Visceral Relaxation Type II* (especially the Color Blue and the Code DSC, representing perfectly the conditions of the **Maximum Trophotropic Activation** and the specular situation to the Color Yellow and the Code WFW of the **Maximum Ergotropic Activation**) is a bit premature and indicates that the subject already needs to recover a lot of energy, or rather, that it has entered a partly defensive phase, only corrupted by the peripheral vasoconstriction. If at this stage were present colors and codes other than those mentioned above, should be taken into consideration the explanations offered in previous and following stages;

6) the *initial phase of the second recovery* shows a very low presence of the Color (Red) and the Code (WSW), typical of the *Anguish by effort for cognitive tasks or physiological control*. This phenomenon can be attributed as well to the fatigue determined by the first considerable hyperventilation phase, as to the subliminal condition of excitement of the system, always assignable to the performance of the first hyperventilation. These physiological responses are quite normal and acceptable and in both cases the beginning of the second hyperventilation should be characterized by the presence of the Color (Yellow) and the Code (WFW) that describe *Hyperactivation/Excitement/Nervousness*. **If this Code would be little (or not) present, we can assume the following causes**:
a) high energy level of the subject, that has the motivation and strength to support the second hyperventilation as if it was still the first. In this case we have to face or must expect modest presence of the Color Red and the Code WSW [typical of the *Anguish by effort for cognitive tasks or physiological control*];
b) very low energy level of the subject, that does not have anymore the motivation and/or the strength to support the hyperventilation. In this case we have to expect the Colors and Codes typical of the *Visceral Relaxation Type I* (DSW = Black; DFW = Green) and, above all, of *Type II* (DSC = Blue; DFC = Cyan);
c) presence of unpleasant physical sensations associated with hyperventilation and possible transition into the Color (Magenta) and the Code (WSC) that characterize the state of *Anxious Apprehension*;
d) a condition that preceeds to this hyperventilation: pre-alarm or excessive psychophysical stress. In this case, the Color White and the Code WFC almost certainly tend to appear, indicating the typical response of *Fear/Alarm/Defense*. This condition may also have been determined by the effort taken to perform the first hyperventilation;

7) the *central and final phase of the second hyperventilation* are the same as in the first hyperventilation, i.e. they are characterized by the Color (Yellow) and by the Code (WFW) that describe *Hyperactivation/Excitement/Nervousness*. In this phase, however, the duration and/or the intensity of hyperventilation may be less, for understandable fatigue determined by the first hyperventilation. If in the *second hyperventilation phase* this Code would be little present (or even absent), the same causes as considered for the *central and final phase of the first hyperventilation* could be hypothesized;

8) the *initial phase of the second recovery* shows a very small presence of the Color (Red) and the Code (WSW), typical of the *Anguish by effort for cognitive tasks or physiological control*. The reasons are the same as those discussed for the *initial phase of the second hyperventilation*. The appearance, in this phase, of the Colors (Blue and Cyan) and the Codes (DSC e DFC) of the *Visceral Relaxation Type II,* attests the need of a deep and intense recovery. As an alternative, also the presence of the Colors (Black and Green) and the Codes (DSW e DFW) typical of the *Visceral Relaxation Type I* is possible. If in this phase there should be the presence of other Colors and Codes, the same causes as considered for the other phases could be hypothesized;

9) the *central and final phase of the second recovery* are characterized by the alternation of the Colors and Codes of the two types of visceral relaxation. It will depend on the energy still available if prevails the *Visceral Relaxation Type I* or *Type II* prevails. If in this phase

there should be the presence of other Colors and Codes, the same causes as considered for the other phases could be hypothesized;

10) the *initial phase of the third hyperventilation* is totally free of the presence of the Color (Red) and the Code (WSW) that characterize the *Anguish by effort for cognitive tasks or physiological control*. The energy resources to manage this Color and this Code could now be no longer there or be nearly absent. On the other hand, a direct transition to the Color (Yellow) and the Code (WFW) that describe the *Hyperactivation/Excitement/Nervousness*, would be possible. In fact, the more likely condition is, however, the one that has been obtained during the experiment: the presence of the Color (White) and the Code (WFC) typical of the *Fear/Alarm/Defense* response. This response could be caused by the pre-alarm condition (or of excessive psychophysical stress) determined by the two previous hyperventilations. In physiological terms, this type of response by the body (or better, by the brain) during this phase (but not in earlier phases, being premature) must be considered quite normal. **It represents a "symptom", an unconscious and automatic signal and an order to "stop". It's the automatic way used by the brain to tell the subject that it must withdraw from that experience, being potentially dangerous or harmful.** It is probably the defense response of the brain in front of the excessive decrease of the Carbon Dioxide concentration in the blood and of the increase of its pH. This condition is associated with peripheral and cerebral vasoconstriction and a momentary hypoxia (lack of the right amount of oxygen in the brain). If in this phase there should be the presence of other colors and codes, the same causes as considered for the other phases could be hypothesized;

11) the *central and final phase of the third hyperventilation* are represented by the Color (White) and the Code (WFC) typical of the *Fear/Alarm/Defense* response. In this case goes the same explanation as for the *initial phase of the third hyperventilation*. If in this phase there should be the presence of other Colors and Codes, the same causes as considered for the other phases could be hypothesized;

12) the *initial phase of the third recovery* shows the presence of the Color (Magenta) and the Code (WSC) that characterize the state of *Anxious Apprehension*. As has been said before, this Color and this Code demonstrate the "slowing down" of the body performed in a "protective" way, for the *defensive* state in which the body finds itself, trying to support an unpleasant emotional experience. It is also an inevitable attempt to contain [*limiting the heart activity* ("**S**">"**F**")] a continuous and pathological response of Fear/Alarm/Defense;

13) the *central and final phase of the second recovery, until the end of the session,* are characterized most of all by the Colors (Blue and Cyan) and by the Codes (DSC and DFC) of the *Visceral Relaxation Type II*. But the present alternation of the Colors (Black and Green) and the Codes of the *Visceral Relaxation Type I* (DSW and DFW) and those of the *Visceral Relaxation Type II* depend on the energy still available. The prevalence of the *Visceral Relaxation Type II* shows that the needs to recovery are higher. If in this phase there should be the presence of other colors and codes, the same causes as considered for the other phases could be hypothesized.

These are the most important considerations concerning the analytical interpretation of the different phases of the psychophysiological profile of the hyperventilation experiment performed by the subject. More information can be obtained by the perusal of the T.T.E. of VNS. From the *Trend of the 6th Order Polynomial Line* (**Pct**. **3**) it is clear that most of the profile and especially the first part, was represented by the Colors (Black and Green) and by the Codes (DSW e DFW) typical of the *Visceral Relaxation Type I*. This means that, despite the sequential hyperventilations and the physical and psychological stress that these have caused, the subject has shown both the energy and the competence to perform the assigned task. In the second part, on the other hand, the profile is characterized by cold colors, especially by the Colors (Blue and Cyan) and by the Codes (DSC and DFC) of the *Visceral Relaxation Type II*. **This change in peripheral temperature shows the effective moment in which the exercise has to be suspended, if it would be desirable to avoid the appearance of the Colors and Codes of the *Anxious Apprehension and the Fear/Alarm/Defense response***.

This conclusion could also and most of all have been reached observing the graph of **Pct. 4** in which are evidenced *the trends of the cumulative intensity of the 8 Codes in time*. The trends of the colored lines Blue and Cyan (i.e. of the Codes DSC and DFC) indicate the *Visceral Relaxation Type II* and tend to increase about one minute just before the third hyperventilation (the one in which the Codes of the *Fear/Alarm/Defense* response are given). By observing this graph it is also possible to obtain a dissociation between the trend of the Color Black and the Code DSW (one of the two Codes that describe the **Maximum Trophotropic Activation**) and the trend of the Color Green and the Code DFW. These two Codes are distinguished only by the letter "**S**" (**S**low heart) and the letter "**F**" (**F**ast heart) and, in normal conditions, they have matching trends. Their dissociation indicates a prevalence of Black and the Code DSW (the Code with the letter "**S**") on the Color Green and the Code DFW (the Code with the la letter "**F**") and evidences the trend of the subject of a cardial relaxation, recovering, even remaining committed to the assigned task.

This last consideration can be also obtained from **Pct. 5** that shows a reading of the Combined Profile of the **GSR**, the **HR** and the **THE** using histograms to represent the *Distribution of Accumulated Intensity of the 8 Codes*. One can easily notice the asymmetry between the histogram of the Colors Black and Green, in which the first one prevails. The same goes for the prevalence of the histogram of the Color Yellow on the Color Red (asymmetry is justified by the higher intensity of the Yellow Color Code involved in the first and second hyperventilation) and of the histogram of the Color White on Magenta (asymmetry is justified by the higher intensity of the White Color Code involved in the third hyperventilation). It should be noted that, compared to the other histograms, the Color blue and Cyan are presented in pairs. This indicates that the subject maintained a more balanced psychophysiological attitude during the *Visceral Relaxation Type II* (that is represented by these colors). On the other hand, from the histograms presented in **Pct. 6** you can summarize the typology of experience from the subject referring to the relation between the *Visceral Relaxation Type I and II Codes* (Parasympathetic Equilibrium) and the ones of Non Relaxation (Sympathetic Equilibrium). The results show clearly that the psychophysiological attitude of the subject, despite the stress caused by it, has had a great contribution to the Parasympathetic Equilibrium and the *Visceral Relaxation Type I and II Codes*.

In the same way the histograms presented in **Pct. 7** summarize the relation between the *Parasympathetic Section Codes* (or of minor Sympathetic activation) and the *Sympathetic Section Codes*. Of the total of the Distribution of the Accumulated Intensity-percentages of the 8 Codes, the percentage of the *Parasympathetic Section Codes* was considerably higher than the *Sympathetic Section Codes*. Even this reading indicates that the subject was not overly upset by

the experience of the three sequential hyperventilations and that he was able to fully recover in time between one hyperventilation and the next one.
From the histograms presented in **Pct. 8** appears more information: the *Codes* (DSW = Black; DSC = Blue) of the *Maximum Trophotropic-Parasympathetic Activation* (or of the Minimum Ergotropic-Sympathetic Activation) were activated much more than the *Maximum Ergotropic-Sympathetic Activation Codes* (WFW = Yellow; WFC = White). If we would like to analyze the results reported in this graph, in the absence of all other graphs seen until now and without any other information, we might conclude that the profile from which data were taken refers to an experience in which from a good general state of relaxation (Type I as well as Type II), or Trophotropic/Parasympathetic activation, appear moments of a high Ergotropic/Sympathetic activation. Starting from the remarks that all Codes normally have a trend of stable and consistent pairs, the same conclusion as above can be made. A profile that would only show the Colors (Black, Green, Blue and Cyan) and the Codes (DSW, DFW, DSC and DFC) of the *Visceral Relaxation Type I and II* would saturate with almost the same percentage the histogram that represents the *Maximum Trophotropic-Parasympathetic Activation Codes* and the one that summarizes the *Activation of the other Codes* (DFW = Green; DFC = Celeste; WSW = Red, Magenta = WSC), without affecting the histogram of the *Maximum Ergotropic-Sympathetic Activation Codes* (WFW = Yellow; WFC = White). Since the difference between the *Maximum Trophotropic-Parasympathetic Activation Codes* and the *Activation of the other Codes* is 2,21 %, we can say that the first condition is almost satisfied, but the second one not at all, because of the presence of a value of 13,45 % realized by the *Maximum Ergotropic-Sympathetic Activation Codes.* These last Codes normally, because of their intrinsic characteristics, aren't represented in pairs (WFW e WFC both have the letter "**F**" and going together they could not balance the **HR**). Their attributed percentage induces us to imagine a profile that has "imbalances", determined by intense but brief cues (caused by abnormalities in breathing or in the **HR** trace, by tremors dued to "autogenic discharges" or by sudden interruptions of the relaxation caused by interferences), of a rather low intensity, but present throughout the whole profile (a much less likely, but possible eventuality), in which the *Maximum Ergotropic-Sympathetic Activation Codes* occurred individually. From **Pct. 9** we can obtain data about the probably activated hypothalamic areas and the intensity of activation. The profile was almost completely saturated by the *Anterior Hypothalamus Activity Codes* (DSW = Black; DFW = Green), corresponding to those of the *Visceral Relaxation Type I*. The *Increase of the Anterior Preoptic Area Codes* (WSW = Red; WFW = Yellow), attributed respectively to the *Anguish by effort for cognitive tasks or physiological control* (present mainly at the start and at the end of the first hyperventilation and poorly at the end the second) and to the *Hyperattivazione/Ecxitement/Nervousness* (present mainly in the central phase of the first hyperventilation, and at the start and the central phase of the second one), were strongly activated during the first two hyperventilations. The *Posterior Hypothalamus Activity Codes* (WSC = Magenta; WFC = White), attributed respectively to the Anxious Apprehension and the *Fear/Alarm/Difense* response, were actually activated almost totally during the entire phase of the third hyperventilation. Finally, the *Decrease of the Anterior Preoptic Area Codes* (DSC = Blue; DFC = Cyan), corresponding to those of the *Visceral Relaxation Type II*, were activated a little during the start of the profile, a bit more at the end of the second recovery and finally, in a more consistent way, at the end of the experimental session. It's interesting to

note that the frequency and intensity of activation of the *Decrease of the Anterior Preoptic Area Codes* grow in proportion to the need for greater physiological recovery. From the point of view of the possible activation of the hypothalamic areas we could draw a fairly clear trend. The profile, especially in more than the first half of the session, was almost completely saturated by the *Anterior Preoptic Area Codes.* This activity was interrupted by the prevailing activation of the *Increase of the Anterior Preoptic Area Codes* during the first two hyperventilations. At this point begins a period of partial activation of the *Decrease of the Anterior Preoptic Area Codes*, in order to recover energy and stabilize the body again. **The change in peripheral temperature, that is accompanied by the activation of these last two codes, marks the actual moment in which the exercise was suspended, in case it's desired to avoid the appearance of the colors and the codes of the *Anxious Apprehension* and the *Fear/Alarm/Defense* response**. The condition of psychophysical stress produced by the first two hyperventilations, however, has already put the body into a pre-alarm condition, preparing the transition to the *Posterior Hypothalamus Activity Codes.* This transition occurs at the start, during and at the end of the third hyperventilation and **represents a "symptom", an automatic and unconscious signal and an order to "stop". It is the automatic way that uses the brain to tell the subject to withdraw from that experience, being potentially dangerous or harmful.** This condition is again followed by the activation of the *Decrease of the Anterior Preoptic Area Codes*, in order to recover energy and stabilize the body again.

The analysis of graphs presented in **Pct. 10** shows that the intensity and the frequency of the *Decrease of the Amygdala and Posterior Hypothalamus Activity Codes* (DSW = Black; DFW = Green; DSC = Blue; DFC = Cyan (i.e. those that, describing respectively *Visceral Relaxation Type I* and *II*, have very low probability of being related to the Amygdala activity) have obtained a much higher percentage than the *Increase of the Amygdala and Posterior Hypothalamus Activity Codes* (WSC = Magenta; WFC = White) and of the other 2 remaining Codes (WSW = Red, WFW = Yellow). Also this reading confirms indirectly the subject's ability to perform the hyperventilation without worrying, as well as the recoveries from the hyperventilations through its visceral relaxation skills. While the first two hyperventilations have involved mainly the *Increase of the Anterior Preoptic Area Codes* (WSW = Red, WFW = Yellow) (in this case, the possible involvement of the Amygdala could not be excluded, but most likely would not be associated with unpleasant emotional experiences), only the last hyperventilation influenced negatively on the profile, involving the *Increase of the Amygdala and Posterior Hypothalamus Activity Codes* (WSC = Magenta; WFC = White), those typical of *Anxious Apprehension* and the *Fear/Alarm/Defense* response. When these last two types of Codes are activated, the probability of a correlation of the activity in the Amygdala of unpleasant emotional experiences are certainly very high.

Finally, from the last graph (**Pct. 11**) can be obtained information about **emotional correlates of physiological simultaneous activity** of the **GSR**, the **HR** and the **THE**. The highest percentage was obtained by the Codes and the Colors (DSW = Black; DFW = Green) that describe the recovery after the first two hyperventilations, those of the *Visceral Relaxation Type I*. Followed by those of the *Visceral Relaxation Type II* (DSC = Blue; DFC = Cyan), but in a lower percentage, which primarily describe the recovery after the last hyperventilation. The next in the row was the percentage of the Color (Yellow) and the Code (WFW) emerged in particular during the central

phase and the end of the first two hyperventilations. This Color and this Code are related to the *Hyperactivation/Excitement/Nervousness*. The next-highest percentage is the one of the *Anguish by effort for cognitive tasks or physiological control* (WSW = Red), that describes most of all the start (and partly the end) of the first two hyperventilations. The penultimate percentage is the one of Fear/Alarm/Defense (WFC = White), extensively involved during the whole phase of the last hyperventilation. Finally, the percentage of the *Anxious Apprehension* (WSC = Magenta) is the lowest one and was realized at the start of the last recovery.

Conclusions

In the introduction was stated that, from the psychophysiological point of view, hyperventilation is a very interesting phenomenon that could become, by elaborating standardized protocols, a privileged model for quantitative and qualitative evaluation of the psychophysiological activation for diagnostic, prognostic and therapeutic purposes. The three sequential hyperventilations are recognized as a privileged model for quantitative and qualitative evaluation of the psychophysiological activation; indeed, in about just 15 minutes the 8 Colors and the 8 Principal Codes were activated, in quantitative and qualitative time sequences, that can be widely interpreted by the clinical point of view. By activating all the Principal Codes and their respective Colors, has been reached the objective of providing clear operational information about how to apply, in the field of psychophysiological evaluation, the Trichromatic Theory of Equilibrium of the Vegetative Nervous System and its innovative computerized program. From the clinical point of view the differences in the same subject (in time and/or in different health conditions) or between different subjects in the quantity and quality of the peripheral response to hyperventilation (or more sequentially performed hyperventilations) may be significant. Depending on the differences of the previous state of health of the subjects, their neurobiological predisposition to respond in a certain way rather than in another and the psychological interpretation of physiological changes that accompany hyperventilation, the last one may very well be considered as a privileged model to draw conclusions for diagnostic, prognostic and therapeutic purposes. Concluding: the results of the experiment on the single case that was proposed inspire to deepen the argument and to increase the interest in scientific research in this direction.

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