THE FUTURE OF PERIPHERAL BIOFEEDBACK:

THE TRICHROMATIC THEORY OF EQUILIBRIUM

OF THE VEGETATIVE NERVOUS SYSTEM

by

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Introduction

The aim of this work is to present, in details, the fundamental theoretical principles related to the **Trichromatic Theory of Equilibrium of the Vegetative Nervous System** (**T.T.E. of VNS**), an application of the **Trichromatic Theory of Equilibrium of Systems** (**T.T.E.S.**) on the analysis of the Vegetative Nervous System.

The **T.T.E. of VNS** is a *new theory* and an *innovative method* derived from computerized processing of peripheral biofeedback data. This theory and its method establish a real innovation in this field. The **T.T.E. of VNS** states that *it's possible to observe, to analyze, to check and to modify, in real time, the status of the dynamic balance between the Sympathetic and the Parasympathetic section of the Vegetative Nervous System*.

This work is published on the website www.ttesystems.eu and the major part of its content has been presented at the **14th Annual Biofeedback Foundation of Europe (BFE) Meeting**, Rome, 2010. The experimental part of this work is independently published on the same website and is called "***The hyperventilation: a privileged model for a quantitative and qualitative valuation of the psychophisiological activation with the Trichromatic Theory of Equilibrium of the Vegetative Nervous System***".

Finally, some of the fundamental theoretical principles of the **T.T.E. of VNS** here described and the clinical and experimental study of a treatment of a sexual assault are already published in the above mentioned website and have already been discussed in an article entitled "***The Peripheral Biofeedback and the Trichromatic Theory of Equilibrium of the Vegetative Nervous System***" [whose contents have been introduced at the **6th International Congress of Cognitive Psychotherapy** (ICCP), Rome, 2008].

The Vegetative Nervous System

The *Nervous System* (NS) can be divided schematically into a central part, called *Central Nervous System* (CNS), that includes the *Brain* and *Spinal Cord*, and a peripheral part, called *Peripheral Nervous System* (PNS), that includes the *Somatic Nervous System* (SNS) and the *Vegetative Nervous System* (VNS) or *Autonomic Nervous System* (ANS).

The **SNS** innervates the skeletal muscles and receives afferents from them and from the skin; its task is to control the major part of the activities that requires movement and execution of highly integrated behavioral sequences.

The **VNS** innervates the endocrine glands, the exocrine gland and the smooth musculature of the heart and of the internal organs; its task is to regulate the visceral activities, among them the heart rate and the blood pressure, the size of blood vessels, the motility and secretion of the gastrointestinal system, elimination of urine, the sweating and control of body temperature. For a long time this system was considered uncontrollable by will-power, that's why it's called *autonomous.* Nowadays it's nearly sure that also these functions can be partially modified by specific voluntary training.

The VNS is divided into two sections with general antagonist operations:

1) The **Sympathetic Section** originates from the sympathetic motor neurons of the lateral horns of the spinal cord's gray matter and has primarily excitatory functions in the areas above the diaphragm and inhibitory in the areas below it. This section supplies fibers to all the autonomic effector organs and has, because of its particular anatomical characteristics, the tendency to common reactions that causes the answer of the entire organism. *The main effects showed by the activation of the sympathetic section are correlated to the modification of the following* ***specific physiological parameters***: rise of the heart rate, increase of blood pressure and the stroke volume, cutaneous vasoconstriction, activation of the sweat glands and increase of the skin conductance, the release of glucose by the liver and increase of its concentration in the blood, decrease of the peristalsis and the tone of the intestine, dilatation of the bronchial muscles, pupillary dilatation, ejaculatory reflex, increase of sphincter tone, increase of the secretion of the adrenal medulla, contraction of the arrectores pilorum, mobilization of the energy reserves, increase of the basal metabolic rate, increase of the muscle glycolysis and of the blood clotting.
   To summarize: the sympathetic section is primarily involved during the muscle activity, in the condition of energy consumption and the utilization of body resources and, therefore, in the activation needed to cope with emergencies and to prepare for action (ergotropism);

2) The **Parasympathetic Section** originates from the brainstem and the sacrum spinal cord, and has primarily excitatory functions in the areas below the diaphragm and inhibitory in the areas above it. This section innervates all the autonomic effector organs, except for the adrenal medulla, the sweat glands, the smooth musculature of the spleen, the cutaneous blood vessels and the skeletal muscles. Contrary to the sympathetic section, the parasympathetic one has much more localized reactions in specific organs or glands and particularly stimulates the bile vessels, the gallbladder, the ureter and the urinary bladder. *The main effects showed by the activation of the parasympathetic section are correlated to the modification of the following* ***specific physiological parameters***: reduction of the heart rate and of the stroke volume, decrease of the blood pressure, increase of the peristalsis and the tone of the intestine, constriction of the bronchial muscles, pupillary constriction and penile erection.

The parasympathetic section is primarily involved during the accumulation of organic reserves, in the conservation of energy, in the maintenance of normal basal functions, in all the conditions of rest, of relaxation and in deep sleep (trophotropism).

The transmission of the nerve impulse in the VNS is guaranteed by the release of specific neurotransmitters. All the autonomic preganglionic fibers, sympathetic and parasympathetic, release acetylcholine. Regarding the postganglionic fibers, the parasympathetic ones release always acetylcholine, while the sympathetic ones release *adrenaline* (epinephrine) or *noradrenaline* (norepinephrine). An exception are the sympathetic preganglionic fibers that innervate the sweat glands, they release acetylcholine (only those of the palm of the hand and the plantar release adrenaline). The activation of the sympathetic section increases the secretion of the adrenal medulla, releasing large quantities of adrenaline in the bloodstream and a smaller quantity of noradrenaline. *Adrenaline*, compared to *noradrenaline*, has major effects on the metabolism and on the cardiac activity, but minor effects on the vasoconstriction in the muscles. Because of this last reason *noradrenaline* is more involved, compared to *adrenalina*, in the increase of peripheral vascular resistance and therefore in the increase of the blood pressure. To summarize: the two systems are different also for the neurotransmitter activity, primarily *adrenergic* for the Sympathetic Section and *cholinergic* for the parasympathetic one.

Every internal organ has a double innervation, sympathetic and parasympathetic, and the normal functioning of each organ is a result of the balanced action of the two sections. The antagonist functioning of the Sympathetic and the Parasympathetic Section of the VNS determines a ***constant state of dynamic equilibrium*** that allows a very accurate regulation and control of the visceral activity. This state of constant dynamic equilibrium can be more or less balanced, that's why the VNS defines it as "autonomic balance". According to the priority of one arm of the scale to the other, it's possible to distinguish basal activity characteristic frequencies of a Sympathetic Tone or, vice versa, a Parasympathetic Tone.

The control of the vegetative life takes place on several levels of the nervous system: at the level of the *spinal cord*, the *bulb*, the *pontis*, the *cerebellum*, the *hypothalamus*, the *limbic system* and, finally, the *cerebral cortex*.

At the level of the *spinal cord* can be evoked vegetative reflexes independently from the higher centers and among them defecation, urination (without complete emptying of the blatter), sweating, erection, and vasomotor responses to heat and cold.

In the *bulb* and in the *pontis* are located the nuclei that control respiration, blood pressure, heart rate, changes in blood glucose levels, skin vasomotor reflexes, salivation, vomit, deglutition, cough, urination and gastrointestinal peristalsis.

At the level of the *cerebellum* can be caused reactions that modify heart rate, blood pressure and urination.

A different remark should be made concerning the *hypothalamus*, at which level are carried out many important actions of integration of the visceral and somatic functions. The hypothalamus represents the most important anatomical structure of the brain structures involved with the control of the vegetative life, intervening in regulation of body temperature, metabolism and water exchange, sexual responses, sleep-wake cycles, etc. The hypothalamus sends descending nerve fibers to the sympathetic and the parasympathetic nuclei of the spinal cord and the brainstem, and intervenes actively in the regulation of the spinal responses and the nuclei of the bulb and the pontis. In a different way the hypothalamus is involved in the hormonal control of the anterior hypophysis and releases directly hormones into the posterior hypophysis. The hypothalamus also controls the responses in emergency situations, organizing their own viscero-motor reactions of the emotional state. Finally, the hypothalamus receives information from the cerebral cortex and the reticular formation, and is influenced by the blood concentration of insulin and glucose. The hypothalamus, because of its extensive anatomical and functional connections, controls directly the VNS and correlates the nerve function with the hormonal one.

In the *limbic system* are located the centers governing the sexual and general emotional behavior; since the limbic structures stand in close anatomic and functional connection with the hypothalamus, in this case a nervous control additional to the hypothalamic one is implemented .

To conclude, at the level of the *cerebral cortex* there is an addition of higher controls on the emotional reactions, and the manifestations of voluntary mobility are supported, mobilizing the vegetative resources.

The criterions of identification and selection of the three parameters of the T.T.E. of VNS

Essential condition for the application of the **T.T.E. of VNS** is the identification of *three specific representative physiological parameters* of the general equilibrium of the Vegetative Nervous System. With the real time values of these three specific representative physiological parameters an innovative psychophysiological profile can be compiled.

In the **T.T.E. of VNS** the identification and the selection of the three parameters predicts a **preliminary selection** of all the most important physiological parameters implicated in the activation of the VNS (see in the paragraph above "*The VNS is divided into two sections with general antagonist operations*:").
Completed the **preliminary selection**, according to the general principles established by the **T.T.E.S.** (for further information have a look at the section "T.T.E.S." of the Website www.ttesystems.eu) in the **T.T.E. of VNS** the identification and the selection of the three physiological parameters have to conform:

1) to the condition that they, together and in absence of other parameters, may suffice to **describe the trend of maximum activation of the Sympathetic Section of the VNS**;

2) to some criterions of the **Trichromatic Theory of Vision of Colors** by *Young* and *Helmholtz*;

3) to the relationship between **Work**, **Energy** and **Heat** of the **Classical Thermodynamics**.

Concerning the first condition (**nr. 1**), it's necessary to select three parameters that are always present in the condition of maximum activation of the Sympathetic section of the VNS. These parameters have to represent that condition in a sufficient and unequivocal way.

Related to the **Trichromatic Theory of Vision of Colors** by *Young* and *Helmholtz* (**nr. 2**) the selection of the three parameters is determined by their fields of physiological action, which have to be:

a) partially overlapped (or sufficiently separated);

b) representative of the general operation of the VNS.

Referring to the condition of partial overlapping of the fields of physiological action **of the parameters** (**nr. 2a**), *the field of action of the* ***SECOND PARAMETER*** *must be partially overlapping the fields of action of the other two, while the fields of action of the* **FIRST** *and the* **THIRD** *need to have a minimal overlap* (for further information have a look at the website www.ttesystems.eu, at the section "T.T.E.S.", the space dedicated to the Trichromatic Theory of Vision of Colors by *Young* and *Helmholtz*).

Concerning the second criterion (**nr. 2b**: the representation of the fields of physiological action of the three parameters comparing to the totality of the field of action of the VNS), the functional combination of the fields of physiological action of the three parameters has to describe the totality of the possible functional states of the VNS.

Referring to the relation between ***Work***, ***Energy*** and ***Heat*** of the **Classical Thermodynamics** (**nr. 3**), the selection of the three parameters have to respect the following conditions:

a) the first parameter has to represent the entity of **WORK** that accomplishes the system;

b) the second parameter has to indicate the quantity of **ENERGY** that is being used by the system;

c) the third parameter has to specify the level of **HEAT** (or *Dispersion of Energy*) of the system.

The ***ideal condition*** for the identification and the selection of the three physiological parameters *is represented by the concomitant adhesion*:

1) to the condition that they adequately describe **the trend of maximum activation of the Sympathetic Section of the VNS** (nr. 1);

2) to the criterions of the **Trichromatic Theory of Vision of Colors** (nr. 2a and nr. 2b) above considered;

3) to the criterions of the **Classical Thermodynamics** above considered (nr. 3).

As an alternative *it's also possible to make the selection* ***if only the first two conditions*** *are being respected.* At the contrary *the selection cannot be considered adequate if these conditions are missing and only the criterions of the* **Classical Thermodynamics** *are respected.*

The three parameters of the VNS

For the analysis of the VNS have been chosen the following *three specific physiological parameters:*

1) **Digital Skin Conductance** (**G**alvanic **S**kin **R**esponse or **GSR**), representation of the exclusive activation of the Sympathetic Section of the VNS;
2) **Heart Rate** (**HR**), expression of the balanced activation of the two sections, Sympathetic and Parasympathetic, of the VNS;
3) **Skin Temperature** (**THE**), that indicates the exclusive activation of the Sympathetic Section of the VNS.

The identification and the selection of the three parameters has been made respecting in the best way possible the ***ideal condition*****, the concomitant adhesion at the numbers *1, 2 (2a and 2b) and 3*** indicated at the end of the precedent paragraph.

The assumption that the **GSR**, **HR** and **THE** describe adequately **the trend of maximum activation of the Sympathetic Section of the VNS** (**nr. 1**) has been respected; in fact, these parameters are always present in this condition of activation and represent them in sufficient and unequivocal way.

Physiologically, the activation of the Sympathetic Section of the VNS is associated with the involvement of the Posterior Hypothalamus.

Facing a stimulus, event or perceived situation (consciously or unconsciously) such as threatening, the **Amygdala** activates the **Posterior Hypothalamus**, which mobilizes the **pituitary-adrenocortical axis**.

The activation of this axis causes an increase in *adrenaline* and *noradrenaline* in circulation. Both of these neuromediators directly influence **cardiac activity**, but the *adrenaline* increases in a greater measure the heart rate (**HR**) and the cardiac output.

The sympathetic postganglionic fibers that innervate the **sweat glands** (of the palm of the hand and the plantar) increase the release of adrenaline and cause a direct increase in the values of the **GSR**. The increase of circulating *noradrenaline* increases very much the **peripheral vascular resistance** (peripheral vasoconstriction) and produces an increase in blood pressure and lower peripheral temperature (**THE**). Maintaining high levels of *adrenaline* and *noradrenaline* in the circulation strengthens the **Amygdala** activity and the course of certain physiological reactions of the **Posterior Hypothalamus**.

To conclude, **the trend of maximum activation of the Sympathetic Section of the VNS** is always sufficiently and unequivocally described by:

1) **Increase** of the **GSR** values (⇧);
2) **Increase** of the **HR** values (⇧);
3) **Decrease** of the **THE** value (⇩).

This ***specific response concomitant trend*** of the three parameters characterizes the ***Response of Defense or Alarm*** to stimuli, events or circumstances considered threatening by the subject for its psychophysical integrity. Note that the stimuli can be both *internal* (from certain thoughts, mental images, fantasies, sensations, hallucinations, etc.) and *external* (originating from sensory perception caused by actual variations of the stimuli present in the environment).

Related to the **first of the two criterions** of the **Trichromatic Theory of Vision of Colors** (**nr. 2a**), the selection is standardized to the requested condition of <u>partial overlapping of the physiological fields of action of the three parameters</u>, that is of the presence of sufficiently separated action-areas.

The partial overlapping of the physiological fields action between **HR** (second parameter), **GSR** (first parameter) and **THE** (third parameter) is realized because these three parameters have also physiological areas of *functional autonomy* (this happens when the variation of the values of the three parameters don't influence each other). Nevertheless, the variations of the **HR** (to attribute to the balanced action of both the sections of VNS) *at a certain level of intensity*, *seem to affect at the same time and much easier* those of the **GSR** and of the **THE** (to attribute only to the action of the Sympathetic section of VNS). These peculiarities of the **HR** justify its *central location* and the

feature of the second parameter (for more details concerning this, please visit the Website www.ttesystems.eu, under "T.T.E.S.", in the space dedicated to the Trichromatic Theory of Vision of Colors by *Young* e *Helmholtz*). Besides, variations of the **HR** seem to engrave much more on the fluctuations of the **GSR** and of the **THE** than generally do the variations of the **GSR** and the **THE** on the **HR**. Finally, values of **GSR** and **THE** may also vary widely without influencing each other, as we shall see later on in this article, where the *muscle and visceral relaxation* is described, with *increase* and *decrease of peripheral temperature*.

Referring **to the second of the two criteria** of the **Trichromatic Theory of the Vision of Colors** (**No. 2b**) – the representation of the fields of physiological action of the three parameters compared to the entire field of action of the VNS - *the functional combination of fields of action of the* **GSR**, *the* **HR** *and the* **THE** *is likely to describe all possible functional states of the VNS.*
Determining the trend of maximum activation of the Sympathetic Section of the VNS

[**I**ncrease of the **GSR** (↑), **I**ncrease of the **HR** (↑), **D**ecrease of the **THE** (↓)],

you can **identify the opposite trend, the one of less activation**

[**D**ecrease of the **GSR** (↓), **D**ecrease of the **HR** (↓), **I**ncrease of the **THE** (↑)].

As was mentioned at the beginning of the paragraph, the **GSR** and **THE** are physiological parameters under the ***exclusive tonic control of the Sympathetic Section of the VNS***, while the **HR** expresses the balanced activation of the two sections, the Sympathetic and the Parasympathetic one**.**
The trend of minor activation of the Sympathetic Section of the VNS therefore corresponds to a concomitant and progressive:

a) **decreased tonic activation** of the *eccrine sweat glands*, which leads to a *reduction in skin conductance* (**GSR**);

b) **decreased tonic activation** of the *tunics of the smooth muscles of the blood vessels*, which leads to an *increase of peripheral temperature* (**THE**);

c) **decreased activation of Sympathetic cardiac fibers and increased activation of Parasympathetic cardiac fibers** (vagal), which leads to a *decrease of the* **HR.**

From the theoretical point of view, the **trend of minor activation of the Sympathetic Section of the VNS** may not correspond directly with its opposite, that is with the **trend of maximum activation of the Parasympathetic Section**; however, the **trend of minor activation of the Sympathetic Section** corresponds to **the progressively minor tonic response of the Sympathetic Section**, which reaches, in certain circumstances, its *functional limit*. By definition, the VNS is considered a "balance", so what's wrong on one side of the balance, must be good at the other side. The logical consequence is that **a progressively minor tonic response of the Sympathetic Section** increases, more or less directly, the weight at the other side of the balance, favoring a more gradual activation of the **Parasympathetic Section**. Clearly, the *functional limit* of the **minor tonic response of the Sympathetic Section** gives indirect important indications referring to the level of activation of the **Parasympathetic Section**: *the more the tonic activation of the **Sympathetic Section** will be close to its functional limit, the more the balance of the VNS will be moved to an activation of the **Parasympathetic Section.*** To conclude, also if theoretically the **trend of minor activation of the Sympathetic Section of the VNS** doesn't correspond directly to the **trend of maximum activation of the Parasympathetic Section**, it is not wrong to use the trend of progressive minor tonic response of the **Sympathetic Section** to determine (even indirectly) the level of activation of the **Parasympathetic Section.**

Referring to **the relationship between Work, Energy and Heat** of the **Classical Thermodynamics** (**nr. 3**), the selection of the three parameters respected as much as possible, the three requested conditions.

The **GSR** represents the entity of **WORK** accomplished by the *Sympathetic section of the VNS*.

In the Classical Thermodynamics "*work*" means "the directional movement of an object or a collection of objects" and is the result of applying a particular *force*, in a particular *direction* and for a particular *distance*. On the contrary, the "*heat*" causes "an occasional movement of an object or a collection of objects."

Therefore the **T.T.E. of VNS** considers the increase of the **Skin Conductance** an indicative event of *motion increase* (or, in physiological terms, activation), *directional* (i.e. only the Sympathetic part) or *non-occasionally*, of the VNS involving certain glands, organs and/or body areas (*spatial distance*) for a specific period (*temporal distance*).

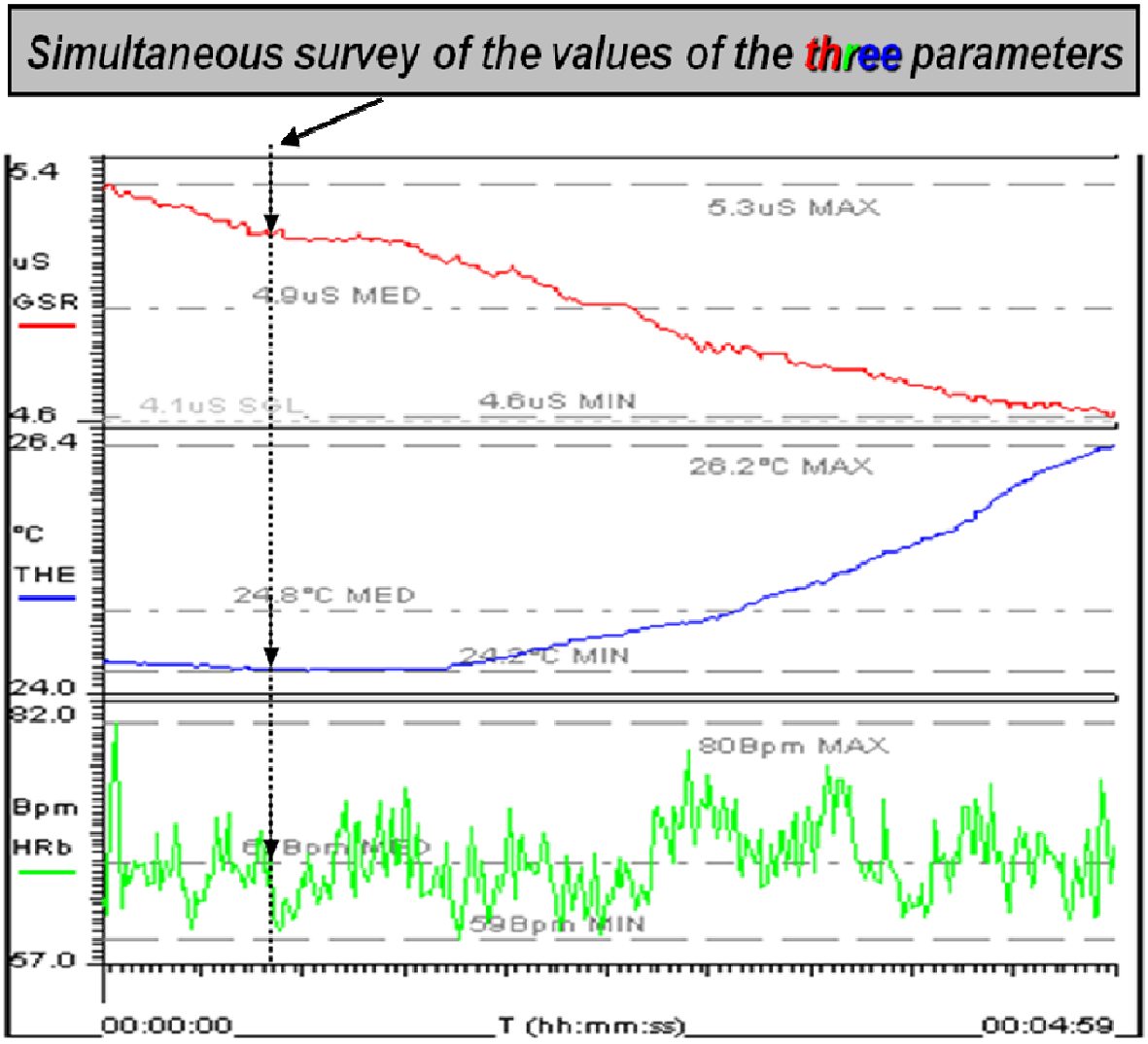
On the other hand the **HR** indicates the amount of **ENERGY** (i.e. the *force able to perform work and produce heat*) using the VNS to produce work and maintain a dynamic balance between the Sympathetic and the Parasympathetic section.

The **THE** specifies the **HEAT** level (or *Energy Dissipation*) of the VNS (i.e. of the whole body more or less stimulated by the activation of the VNS), either engaged in work, or trying to save energy. In general the VNS helps, as all systems, when engaged in work (to increase the Sympathetic activity and/or decrease the Parasympathetic activity) to generate heat and needs to disperse it into the external environment (also through peripheral vasodilatation); on the other hand, when the VNS is trying to save energy (to decrease the Sympathetic activity and/or increase the Parasympathetic activity) reduces its production of heat and/or tends not to disperse it into the environment. However, in some circumstances, these general rules seem to be contradicted. For

example during the ***Response of Defense and Alarm*** there is **a marked decrease in the values of the THE** (⇩)**.** In fact, there is no contradiction, because this peripheral vasoconstriction represents the modality in which the VNS prepares the organism to fight or to flee. In this case the organism needs to maximize its energy resources and minimize its *Energy Dissipation* (i.e. *Heat*). In addition, to act effectively and avoid potential bleeding following a trauma or an injury, the organism must have a larger amount of blood in the muscles (rather than in the viscera) and smaller quantities in the peripheral districts (especially the skin). Similarly, finding **an increase in the values of THE** (⇧) **during relaxation** is not representing an *Energy Dispersion*; at the contrary, this peripheral vasodilatation is determined by the temporary relaxation of muscles during the first phase of relaxation (*muscle and visceral relaxation with increase of peripheral temperature*) and spraying of more peripheral districts (especially the skin). Maintaining in time the state of relaxation, the peripheral vasodilatation will be replaced by a modest but effective and continuous peripheral vasoconstriction (*muscle and visceral relaxation with decrease of the peripheral temperature*) which allows an adequate thermal equilibrium (by reducing inappropriate heat losses) and real energy savings.

The instrumental and computerized survey of the values of the three physiological parameters and the preparation of the text file

The method of the **T.T.E. of VNS** is based on the computerized analysis of data collected simultaneously from biofeedback activity of the **GSR**, **HR**(o **HRB**) and **THE** (**Pct. 1**).



Pct. 1

Regarding the time of instrumental detection of the values of the three parameters it is essential to comply with a condition of systemic coherence.

There is a **systemic coherence for the choice of timing of the instrumental detection of the values of the three parameters**, when following a logical reasoning which takes into account the whole system that you want to analyze. If one doesn't respect this condition there is the risk to analyse together all the values that reflect (more or less precisely) the trend of individual

parameters, rather than the system in its entirety. To understand better this concept here follows an example. Generally, in condition of rest, the **HR** of adult woman is approximately 75 bpm (men 70 Bpm) and the temporal distance between one QRS complex (all three waves that follow one another which corresponds to depolarization of the ventricles of the heart) and the next one is about 800 milliseconds (0,8 seconds). The **GSR** and the **THE** are parameters that can be measured continuously, while the value of the **HR**, also in case it is measured continuously, is always determined by the time difference between QRS complexes. This means that in the temporal distance between two QRS complexes (about 0,8 seconds) **the value of the HR remains always the same**, **while the values of the other two parameters can change.** For a subject at rest these temporal distances between the QRS complexes, variable according to the age or state, are rather stable. For analyzing the equilibrium of the VNS monitoring the progress of the **GSR**, the **HR** and the **THE** and following the condition of **systematic coherence** for the choice of timing of the instrumental detection of the values of the three parameters, it is essential to use as time reference the average time of distance between the two QRS complexes in an adult subject at rest (namely about 0,8 seconds). Generally, the traded biofeedback instruments provide the possibility to effectuate also the **average acquisitions of one datum per second**, the time value that is closest to that of about 0.8 seconds required for the condition of **systemic coherence.** *Using this average data acquisition time [look at the next page **Pct. 2**, "Average time"] the unnecessary, redundant or even misleading duplication of the **GSR** and **THE** values obtained during the two QRS complexes is neutralized, and the overall trend detection of the **HR** is harmonized.* Concluding, setting the **time average at 1 datum per second** we'll have the best possible condition of **systemic coherence** for the analysis of the VNS equilibrium effectuated by monitoring the progress of the **GSR,** the **HR** and the **THE** and using the biofeedback instruments actually in trade.

As we will see in the next paragraph "*How to use the application of the T.T.E.S. TEST ONLINE*", colleagues interested in the collaboration and experimentation can use the application **TEST ONLINE** on the website www.ttesystems.eu. Using this application **it's possible to use free online the T.T.E.S.-software.** With this software scientists of all disciplines can elaborate their experimental data comfortably from their laboratories.

Colleagues using the **PHYSIOLOGICAL PARAMETERS** of the **GSR**, the **HR** and the **THE** interested in analyzing the VNS with the **T.T.E.S.** software have to **prepare and submit a text file** (*file. txt*) following the guidelines given below.

Generally, any instrument of biofeedback provides access to a text file generated during data acquisition in which the values of the three parameters over time are reported. These reported data in the *file .txt* can be either spatially organized or can be expressed differently by different manufacturers of biofeedback instruments and their supplied data processing software.

Data reported in the *file .txt* may differ for:

1) *The spatial organization within the worksheet*. For example, in the worksheet of the PSICHOLAB VD13 instrument by SATEM at Rome the spatial data organization is as follows:

File ASCII export sessions
Session 02/11/05 at 19:51
Number of samples : 300
Average time : 1 Second

Events	T(Sec)	EMG(uV)	GSR(uS)	THE(°C)	HR(ms)
Datum	0	25.15	1.77	23.96	795
Datum	1	24.70	1.78	23.96	802
Datum	2	25.34	1.78	23.96	792
Datum	3	24.85	1.78	23.95	766
Datum	4	25.30	1.77	23.95	787
Datum	5	25.06	1.77	23.95	787
Datum	6	25.19	1.77	23.95	790
Datum	7	25.00	1.77	23.95	813
Datum	8	24.54	1.77	23.95	782
Datum	9	24.54	1.77	23.94	804
Datum	10	…….	……	…….	…..
Datum	11	…….	……	…….	…..

Pct. 2

The *first* column is reserved for **Events;** the *second* column for **Time** (Sec); the third column is for Electromyogram data [**EMG**, (uV)]; the last three columns are respectively reserved for the **GSR** (uS), the **THE** (°C) and the **HR** [or **HRb**, (ms)].
A different location of the columns (for example even a simple reversion of the positions of the columns **GSR** and **THE**) or the absence of just one column [for example the one for "**Events**"] will provide data processing software that considers these differences;

2) *Mode of data expression*. In the worksheet of the PSICHOLAB VD13 instrument by SATEM at Rome, **Time** is expressed in seconds, the **EMG** data in microvolt, the **GSR** in microsiemens, the **THE** in degrees centigrade and the **HR** (oR **HRb**) in milliseconds. Different modes of expression of data can be very crucial. For example data on the **HR** (or **HRB**) can be expressed in **milliseconds (ms)** or **in beats per minute (Bpm).** This is a not

unimportant difference, because if the data expressed in *milliseconds* wouldn't be transformed by the processing software in *beats per minute* (the formula is *60000)/ms*), we would obtain an inverted curve of the Heart Rate (indeed, if passes a longer time between one beat and the next one we'll see a lower heart rate);

3) *Punctuation.* The simple replacement of the trivial point by a comma will cause an error during data processing.

For these reasons, colleagues interested in using the **T.T.E.S. TEST ONLINE** need to prepare and submit a *file .txt* with data spatially organized and expressed as follows (**Pct. 3**):

Events	T (Sec)	GSR (uS)	HRb (Bpm)	THE (°C)
Datum	0	1.78	75.32	33.96
Datum	1	1.80	79.25	33.98
Datum	2	1.82	76.10	33.97
Datum	3	1.79	78.59	33.95
Datum	4	1.77	78.50	33.95
Datum	5	1.81	79.01	33.94
Datum	6	1.86	81.44	33.92
Datum	7	1.90	78.31	33.93
Datum	8	1.88	80.48	33.94
Datum	9	1.80	79.09	33.96
Datum	10	------	------	------
Datum	11	------	------	------

Pct. 3

ATTENTION, notwithstanding the foregoing:

Colleagues using the instruments of the company ***SATEM at Rome*** *(PSICHOLAB VD13 and VD13 PSICHOLAB SV)* and those using the tools of ***Thought Technology*** and its ***Biograph Infiniti*** ™ software platform can send the *file .txt* generated by the instruments directly **without making any change**.

Before concluding this paragraph, I want to note that the analysis of the equilibrium of the VNS (effectuated by monitoring the trend of the **GSR**, the **HR** and **THE**) using biofeedback instruments currently on the market raises the question of *accuracy*.

Accuracy is the ability of an instrument to measure correctly the values of the parameters obtained. A measuring instrument is accurate if the effectuated measurements are **error-free constants** that indicate the existence of **sources of bias**.

An instrument may appear ***precise*** because the resulting values may be close together, but may be ***little accurate*** if these values differ from the actual value that we want to measure. The most used example to understand this concept is the one of the meter that, used at a high ambient temperature, stretches dued to thermal expansion and will disturb the measurement.

The bias tends to run constantly in subsequent measurements and is difficult to quantify. If identified, **systematic errors can be corrected in retrospect on the measured value** or, **a priori, adjustment of the measurement or physically removing the sources of bias. The physical elimination of sources of bias** and **adjustment** are error correction procedures that are generally effectuated by manufacturers of measuring instruments, while correcting **the measured value in retrospect** can be realized also by others with the use of **specific software**.

An electronic instrument that works in **areas of very low voltage** and/or for which are required **very high resolutions** can read the background noise of his own electronics or interferences generated by external sources. If these interferences aren't adequately **screened** or **filtered** (this is also possible afterwards using the software), it will have a negative impact especially on the **measuring resolution**, i.e. on the ability of the instrument to detect small variations in the measured parameter.

The kind of error on acquired data *(signal)* caused by **interferences by background electronic noise of the measuring instrument** refers to the concept of the ***Signal/Noise ratio*** (SNR and S / N). The S/N ratio measures how a signal has been corrupted by noise. It is almost impossible to control completely all sources of disturbance, in practice it tolerates a disturbance entity that does not make the measurement non-significant. If the *background-noise* is distributed *randomly*, positive and negative fluctuations are repeated with the same frequency. In that case the measurement uncertainty that the random error introduces is partly neutralized by itself and/or can be reduced and identified through **repeated measurement**. If the *background noise of the instrument* is distributed in a ***non-random way***, it shows the presence of a ***source of bias***. In the valuation of **random errors**, the *Gaussian distribution* of measured values represent the reference standards and the contribution of uncertainty of the reproducibility error is the same as the *standard deviation values*. A non-Gaussian distribution curve leads to the suspicion of bias.

The T.T.E.S.-software is constructed in a way to evidence unambiguously eventually significant deviations from a Gaussian distribution of values. For this reason it represents a safety as well for the fidelity and the accuracy of the analysis of the system you choose to study, as to exclude the possibility of systematic errors attributable to the electronic instruments used to collect the parameters.

Regarding this, the website www.ttesystems.eu, in the section "T.T.E.S.", it will be possible to download an article ("A single view of reality: the Trichromatic Theory of Equilibrium of Systems", paragraph "*Analysis of accuracy of the measuring instrument with T.T.E.S.* ") in which will be explained in detail ***how it is possible to analyze and evidence, using the T.T.E.S.-software, eventual sources of bias related to non-random distribution of background noise of any measuring instrument.***

Clarification on the selection of the three parameters of the T.T.E. of VNS

The selection of the **GSR**, **HR** and **THE** in relation to the analysis of the VNS is just one of the possible selections. It's ***obligatory*** determined by the type of electronic instrument used for their detection [PSICHOLAB VD 13, four channels (EMG, GSR, FC, THE) made by SATEM in Rome].
The use of instruments for different data capture could help the identification and the selection of other parameters, which might also be more appropriate for the analysis of the dynamic balance of the VNS. This explanation is required and very important; possible inconsistencies in results of analysis detectable in the comparison with other modes of analysis of the VNS (for example Heart Rate Variability or HRV), will be reduced to the specific and binding selection of the three parameters as written above and not to the imperfections in the structural architecture or the functional logic of the **T.T.E. of SNV**.

How to use the application of T.T.E.S. TEST ONLINE

To value the tools and the similar or different methods of analysis of the VNS the collaboration between all the colleagues working in this field of research is very important.
Colleagues interested in the collaboration and experimentation can use the application **TEST ONLINE** on the website www.ttesystems.eu. Using this application **it is possible to use free online the software of the T.T.E.S.** With this software scientists of all disciplines can elaborate their experimental data comfortably from their laboratories.

Colleagues using the **PHYSIOLOGICAL PARAMETERS** of the **GSR, HR** and **THE** interested in analyzing the VNS with the **T.T.E.S.**-software need to:

1) prepare a text file with simultaneously collected data of the biofeedback activities of the three parameters. Preparing this file it is important to follow the detailed instructions about the **condition of systemic coherence on the time of the instrumental detection of the values of the three parameters** (average detection of one datum per second)
(See paragraph *"The instrumental and computerized survey of the values of the three physiological parameters and the preparation of the text file");*

2) use the application **TEST ONLINE** as follows:

   a) **sign up, enter username and password**;
   b) **select "Go to test" in the reserved space "For the Physiological Parameters of the GSR (X), HR (Y) and THE (Z)"**.
   This option automatically determines the direction of the trend
   (**I**ncrease ↑ ; **I**ncrease ↑ ; **D**ecrease ↓) of the **GSR**, the **HR** and the **THE** under conditions of **maximum activation of the Sympathetic Section of the VNS**
   (See paragraph *"The three parameters of T.T.E. of the VNS");*
   c) **select** "*Submit file.txt of the parameters X, Y, and Z*" and submit this prepared text file following the instructions in step 1.

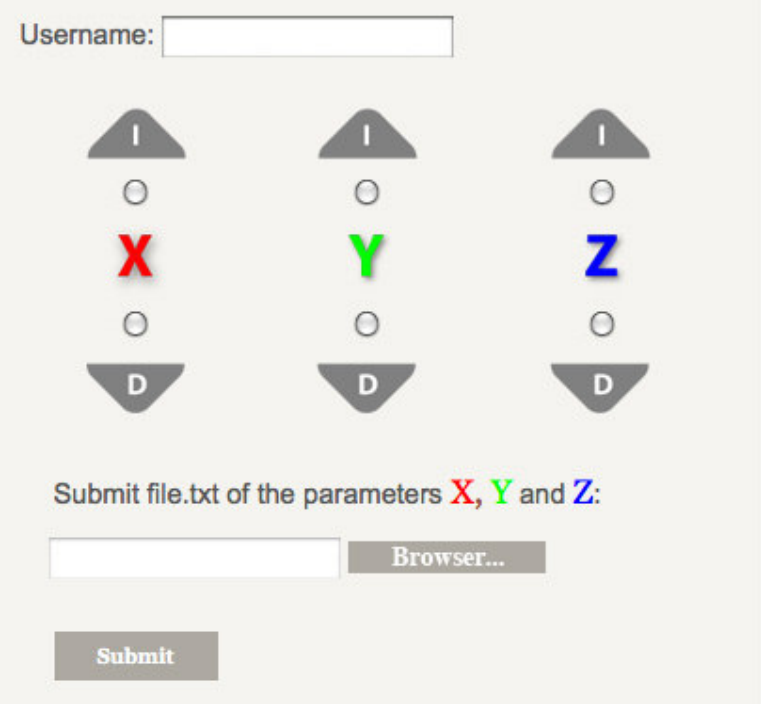
Colleagues using **PHYSIOLOGICAL PARAMETERS DIFFERENT** then **GSR**, **HR** and **THE** interested in analyzing the VNS with the **T.T.E.S.**-software need to:

1) **prepare a text file** with simultaneously collected data of the biofeedback activities of the three parameters identified and selected according to the instructions provided regarding the practice of **screening**
(See paragraph "*The criteria for the identification and selection of the three parameters of the T.T.E. of VNS*").

Preparing this file it's necessary to follow the detailed instructions about the **condition of systemic coherence regarding the time of the instrumental detection of the values of the three parameters**
(See paragraph "*The instrumental and computerized survey of the values of the three physiological parameters and the preparation of the text file*").

2) use the application **TEST ONLINE** as follows:

a) **sign up, enter username and password**;
b) **select "Go to test" in the reserved space "For the PHYSIOLOGICAL PARAMETERS DIFFERENT then GSR, HR and THE"**;
c) **specify the direction of the trend of the three physiological parameters X, Y and Z under conditions of maximum activation of the Sympathetic Section of the VNS**
(See paragraph "*The three parameters of T.T.E. of the VNS*").
To define the direction of the trend, it is sufficient to **establish the direction of the arrow for each parameter** (**I** = **I**ncrease; **D** = Decrease) in the **provided grid** (see Figure xx);
d) **select** "*Submit file.txt of the parameters X, Y, and Z:*" (See **Pct. 4**) and submit this prepared text file following the instructions in step 1.



Pct. 4

The colleagues who want to analyze **ANY SYSTEM** with the **T.T.E.S.**-software need to:

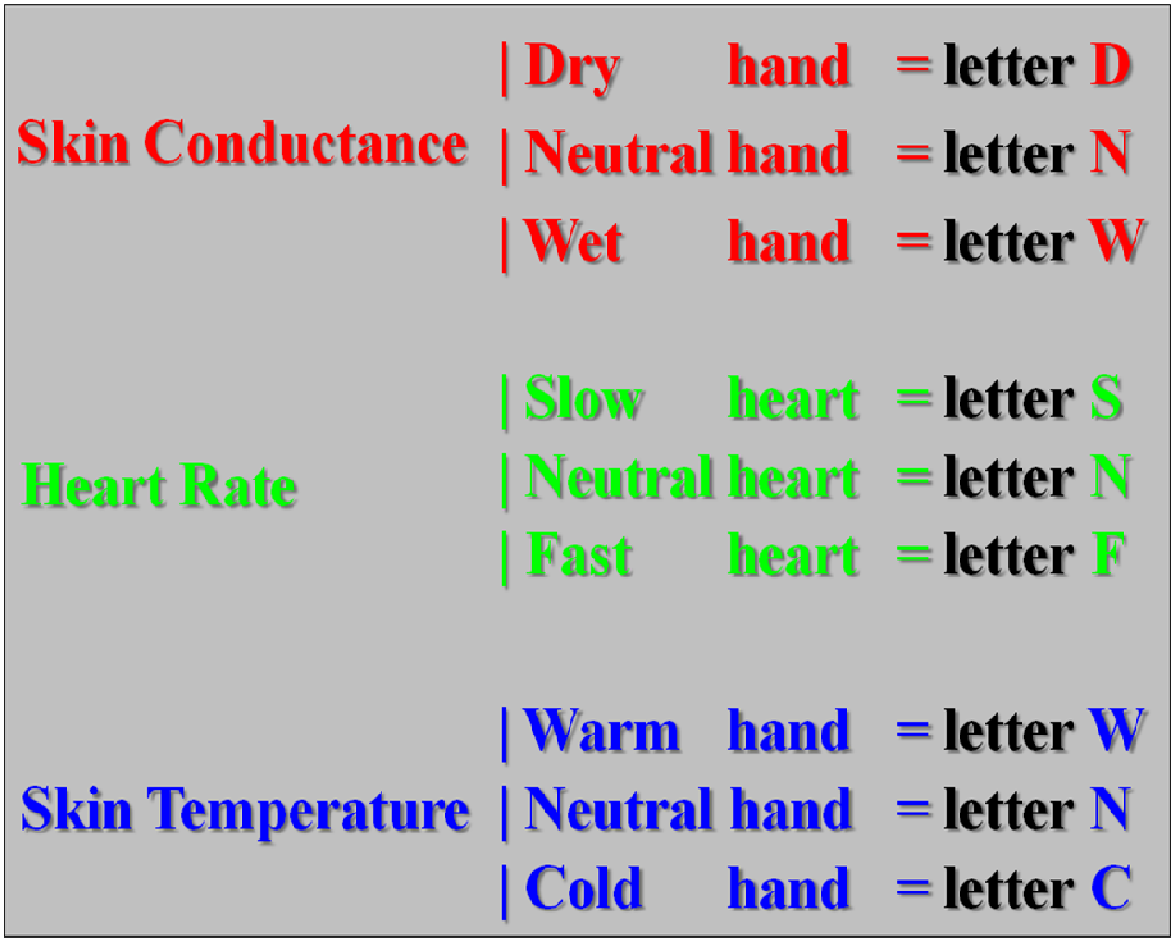
1) **identify and select three specific parameters** (**X**, **Y**, and **Z**) that are representative of the general functioning of the system to be analyzed. The identification and selection have to be made following the instructions provided on the website www.ttesystems.eu
   (See section "T.T.E.S.", article "*One universal vision of reality: the Trichromatic Theory of Equilibrium of Systems*", paragraph "*The criteria for identification and selection of the three parameters of the T.T.E.S.* ");
2) **prepare a text file** with simultaneously collected data of the activity of the **three chosen parameters.** Preparing this file it's necessary to follow the detailed instructions about the **preparation of the text file** and the **condition of systemic coherence regarding the time of the instrumental detection of the values of the three parameters**
   (See the website www.ttesystems.eu, section "T.T.E.S.", article "*One universal vision of reality: the Trichromatic Theory of Equilibrium of Systems*", paragraph "*The instrumental and computerized survey of the values of the three physiological parameters and the preparation of the text file*");
3) use the application **TEST ONLINE** as follows:
   a) **sign up, enter username and password**;
   b) **select** "**Go to test**" **in the reserved space** "**For ANY SYSTEM** ";
   c) **specify the direction of the trend of the three physiological parameters X, Y and Z under conditions of maximum activation of the system that has to be analyzed**
      (See website www.ttesystems.eu, section "T.T.E.S.", article "*One universal vision of reality: the Trichromatic Theory of Equilibrium of Systems*", paragraph "*The criteria for identification and selection of the three parameters of the T.T.E.S.*").
      To define the direction of the trend, it is sufficient to **establish the direction of the arrow for each parameter** (**I = I**ncrease ; **D** = Decrease) in the **provided grid** (See **Pct. 4**);
   d) **select** "*Submit file.txt of the parameters X, Y, and Z:*" and submit this prepared text file following the instructions in step 1 and 2.

The conversion of the values of the three physiological parameters

To simplify the comprehension of the simultaneous trend of the three parameters, at all their variations are associated specific **words**. For example with an increase of the *skin conductance* (**GSR**) is associated the word "**Wet**" (hands), while with its decrease the word "**Dry**" (hands). In case there isn't obtained any variation of the skin conductance the associated word is "**Neutral**" (hands). The same procedure is used for the **HR** and the **THE**. The obtained values of the physiological parameters of the **GSR**, the **HR** and the **THE** are elaborated by the T.T.E. of VNS-software based on this simple classification.

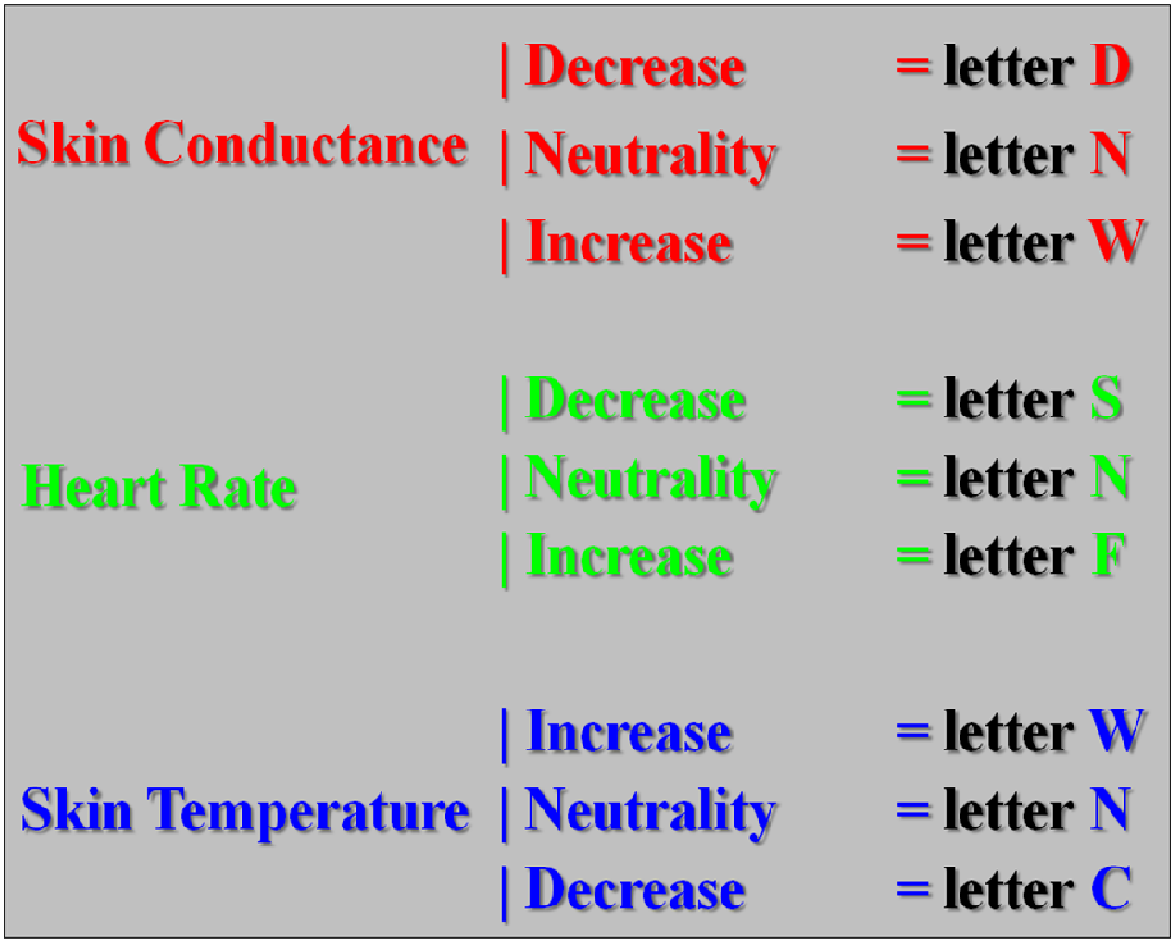
The values of three parameters are converted into **9 Letters**, ***three letters for each index***.

The chosen **letters** correspond to the initials of the specific **words** associated with the physiological variations observed during the detection of each parameter (**Pct. 5**).



Pct. 5

The scheme in **Pct. 5** can also be expressed as described in **Pct. 6**.



Pct. 6

In **Pct. 6** with every variation of the physiological parameters are associated the specific words "**Decrease**", "**Neutrality**" and "**Increase**". For example, with an increase of the *skin conductance* (**GSR**) is associated the word "**Increase**" (letter **B**), while with its decrease is associated the word "**Decrease**" (letter **A**). If no variation of the skin conductance is detected the associated word is "**Neutrality**" (letter **N**). The same procedure is used for the **HR** and the **THE**.

The simultaneous variations of the values of these *three parameters* are successively converted in **27 Codes** [(*3 letters for the **GSR***) *x* (*3 letters for the **HR***) *x* (*3 letters for the **THE***) = *27 Codes*] formed by ***three*** of the 9 Letters: the first letter for the **Skin Conductance**, the second letter for the **Heart Rate** and the third one for the **Peripheral Temperature**.

In **Pct. 7** are listed the **8 Principal Codes**, those used to describe synthetically *all possible functional states of the VNS* (see the next paragraph).

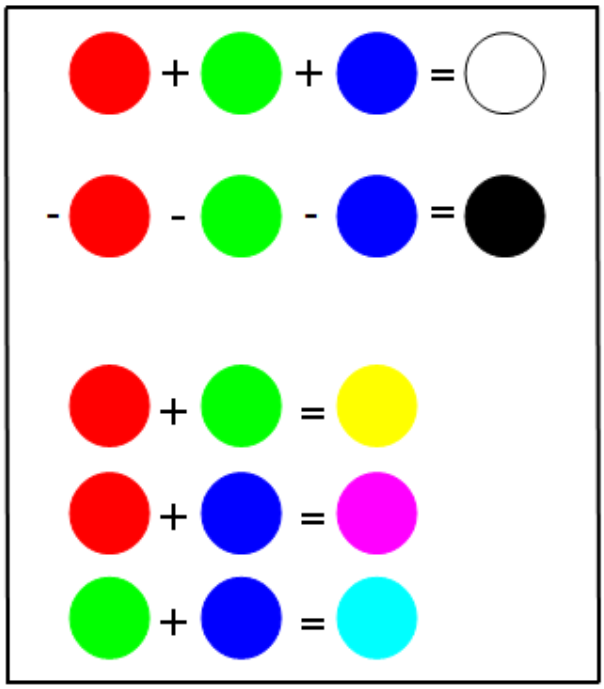
CODES	MEANING OF THE CODES		
DSW	**D = DRY HAND**	**S = SLOW HEART**	**W = WARM HAND**
DFW	**D = DRY HAND**	**F = FAST HEART**	**W = WARM HAND**
DSC	**D = DRY HAND**	**S = SLOW HEART**	**C = COLD HAND**
DFC	**D = DRY HAND**	**F = FAST HEART**	**C = COLD HAND**
WSW	**W = WET HAND**	**S = SLOW HEART**	**W = WARM HAND**
WFW	**W = WET HAND**	**F = FAST HEART**	**W = WARM HAND**
WSC	**W = WET HAND**	**S = SLOW HEART**	**C = COLD HAND**
WFC	**W = WET HAND**	**F = FAST HEART**	**C = COLD HAND**

Pct. 7

For each code is determined a ***Color*** and calculated a ***Value of Intensity***. To determine the ***Color*** and calculate the ***Value of Intensity*** reference was made to the appropriately amended **RGB Color Model** (see next paragraph).

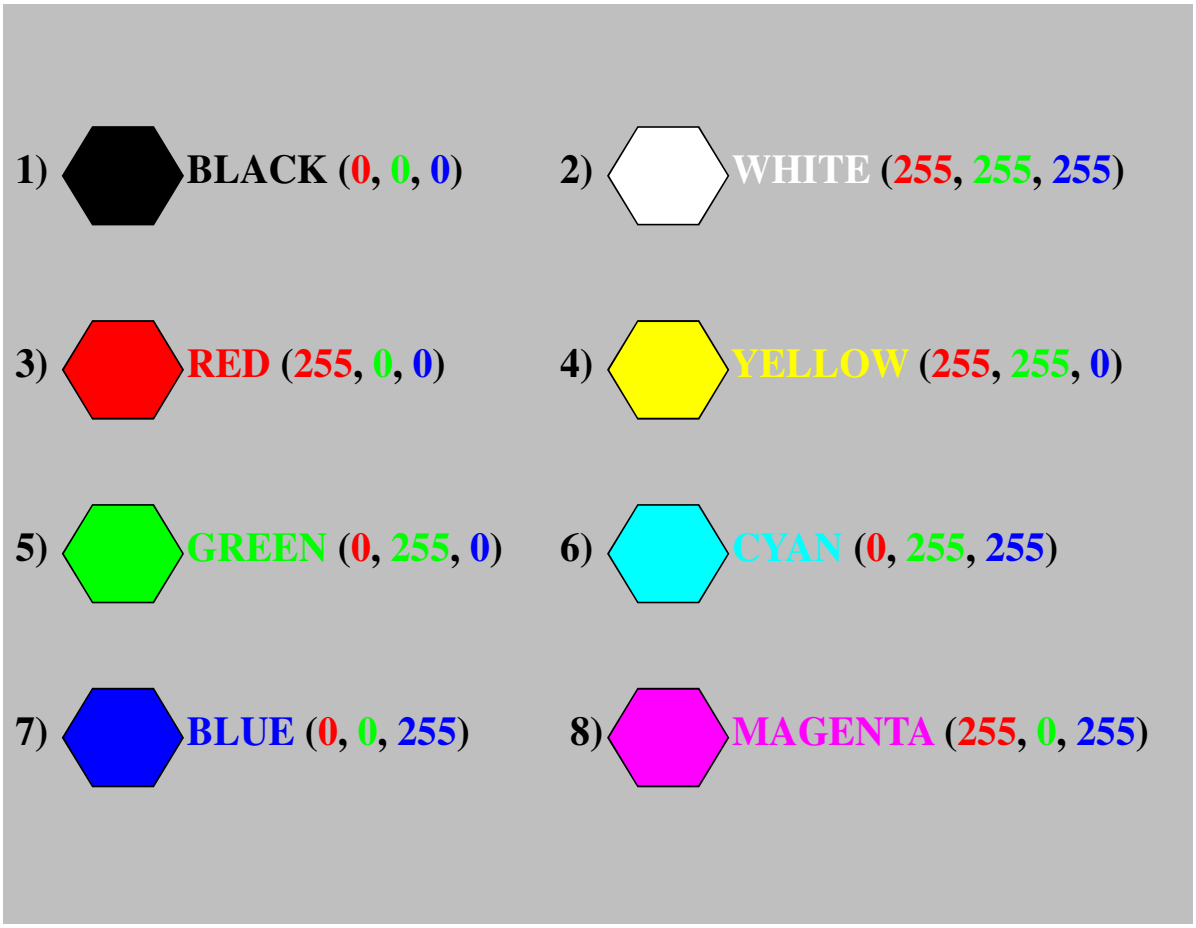
The use of the RGB color model in T.T.E. of VNS

A color model is a method for defining colors. In the theoretical conceptualization of **T.T.E.S.** and in its practical application **the RGB Color Model** was the most appropriate (see website www.ttesystems.eu Section "T.T.E.S.", article "A universal view of reality: the Trichromatic Theory of Equilibrium of Systems" , under "*Use of the RGB color model in T.T.E.S.*"). *In the RGB color model all colors can be reproduced by combining, in various intensities, the light of wavelengths of* ***red***, ***green*** *and* ***blue***. Mixing 100% of all three colors you get white light, while reducing them to zero we get black, the absence of light (see **Pct. 8**).



Pct. 8

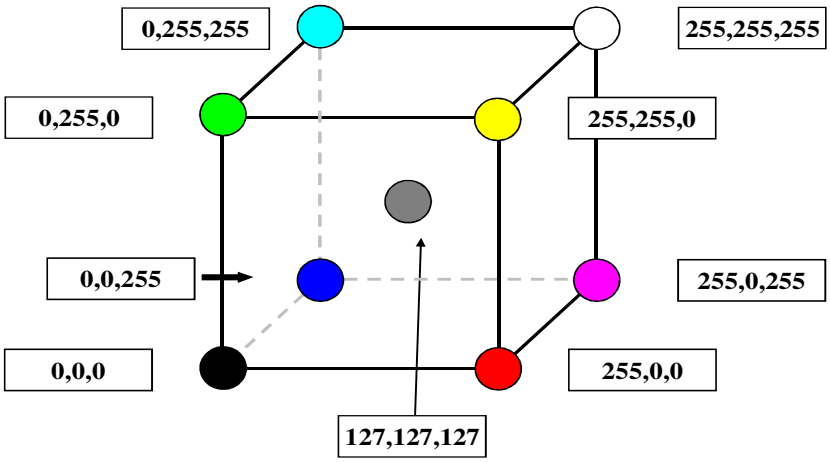
These three colors are known as **RGB** (**R**ed, **G**reen and **B**lue). In the RGB color model, to specify a color, is used a **triad of numbers** (R,G,B) and the mixture of two colors (R_1,G_1,B_1) and (R_2,G_2,B_2) matches with the color (R_1+R_2,G_1+G_2,B_1+B_2). The triads (R,G,B) are represented using numbers that can assume values between 0 and 255. The Triad (0,0,0) corresponds to **black** and the (255,255,255) to **white**, while all other triads with the same values, for example (150,150,150) correspond to a shade of **gray**. Besides **black** and **white,** from the combinations of the numbers 0 and 255 are obtained **six triads** that correspond to **six colors** (maximum saturation and brightness to 50% of scale) of the **standard color wheel** (see **Pct. 9**).



Pct. 9

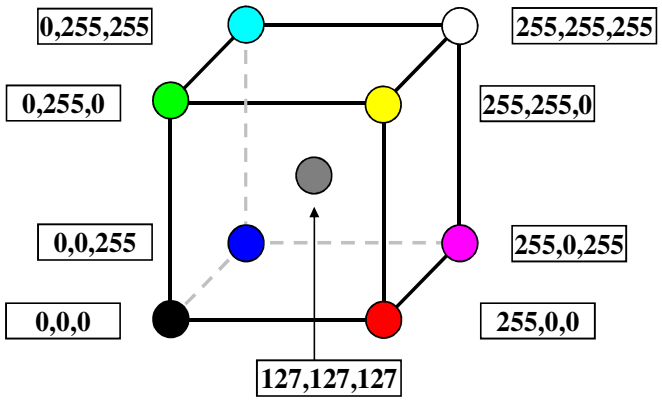
The structural and functional organization of the RGB color model can be effectively represented using the image of a **cube** as a sub-space reference. All ***shades of colors***, specified by a **triad of numbers**, take a ***precise location*** *on the surface or in the area of the cube*.

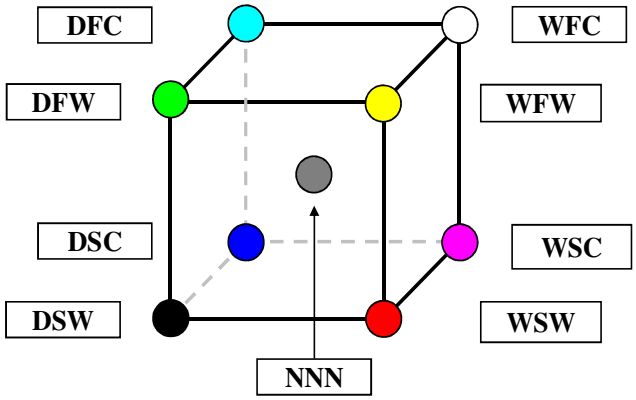
In **Pct. 10**, **eight triads** of numbers specify the positions of the ***eight vertices*** of the cube occupied by **white**, **black** and the **six colors** shown in **Pct. 9**



Pct. 10

In **Pct. 11**, the **8 triads** of numbers and the **8 colors** (**white**, **black** and the **six colors** shown in **Pct. 9**) are associated with **8 Principal Codes** used to *briefly* describe all possible functional states of the VNS. The *gray dot* at the center of the cube (Code **NNN**, triad 127,127,127) represents the position of the VNS when *simultaneous changes in the values of all three parameters* (GSR, **HR** and **THE**) *are not detected*. This condition occurs when, for each parameter, the values taken at time T and those detected at time T +1 remain unchanged.


0,255,255
255,255,255
0,255,0
255,255,0
0,0,255
255,0,255
0,0,0
255,0,0
127,127,127


DFC
WFC
DFW
WFW
DSC
WSC
DSW
WSW
NNN

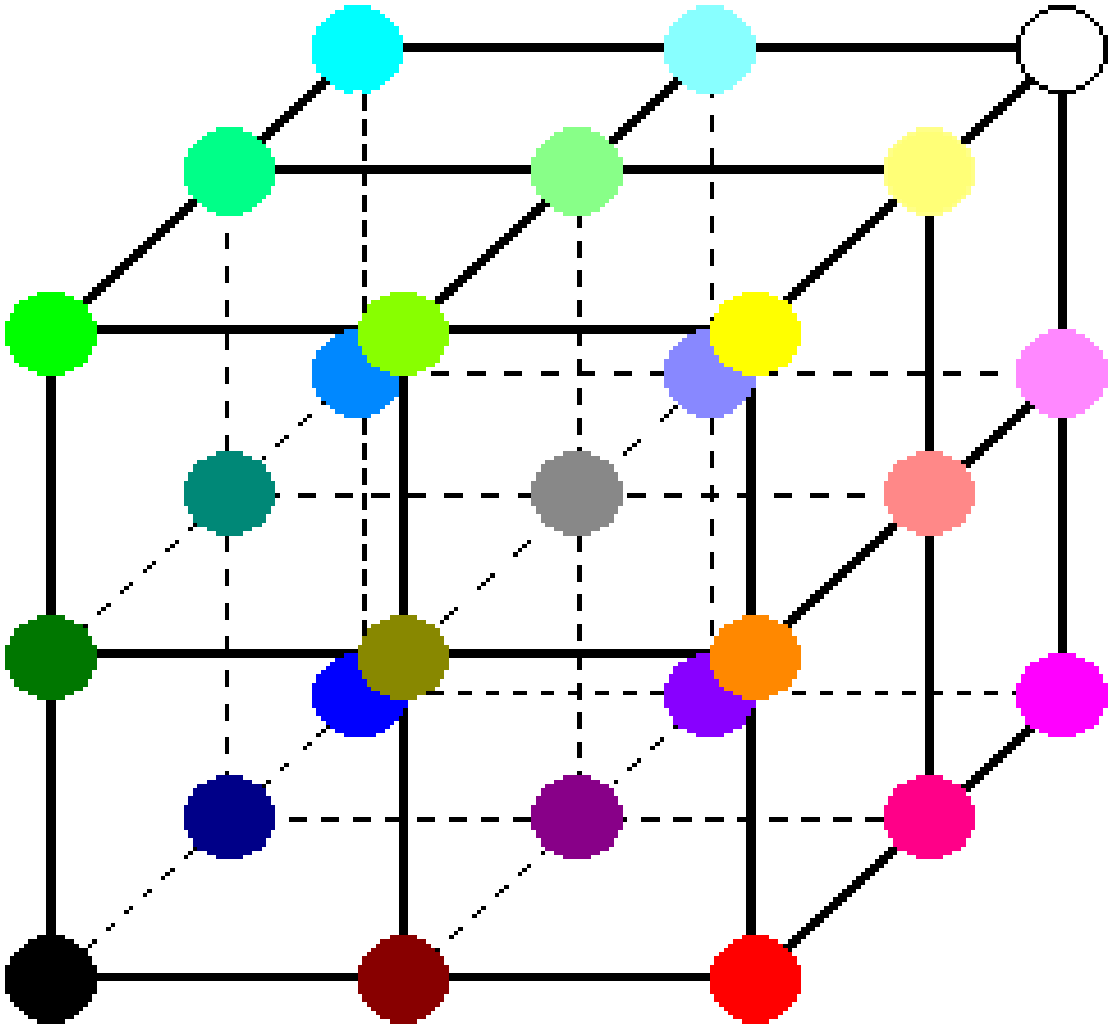
Pct. 11

In **Pct. 12** are schematically summarized the **8 colors** associated with the **8 Principal Codes** and their respective meanings used to briefly describe *all possible functional states of the VNS.*

COLORS	CODES	MEANING OF THE CODES		
	**DSW**	**D = DRY HAND**	**S = SLOW HEART**	**W = WARM HAND**
	**DFW**	**D = DRY HAND**	**F = FAST HEART**	**W = WARM HAND**
	**DSC**	**D = DRY HAND**	**S = SLOW HEART**	**C = COLD HAND**
	**DFC**	**D = DRY HAND**	**F = FAST HEART**	**C = COLD HAND**
	**WSW**	**W = WET HAND**	**S = SLOW HEART**	**W = WARM HAND**
	WFW	**W = WET HAND**	**F = FAST HEART**	**W = WARM HAND**
	**WSC**	**W = WET HAND**	**S = SLOW HEART**	**C = COLD HAND**
	**WFC**	**W = WET HAND**	**F = FAST HEART**	**C = COLD HAND**

Pct. 12

Finally, in **Fig. 13** are represented graphically in the cube the colors and positions of the **27 Codes** used to visualize all possible combinations [(*3 letters for **GSR***) *x* (*3 letters for **HR***) *x* (*3 letters for **THE***) = *27 Codes*] of the functional variations of the simultaneous activation of the three parameters. The coordinates to define the colors and positions in the cube are determined by calculating the **Value of Intensity** of the simultaneous variations of the three parameters.



Pct. 13

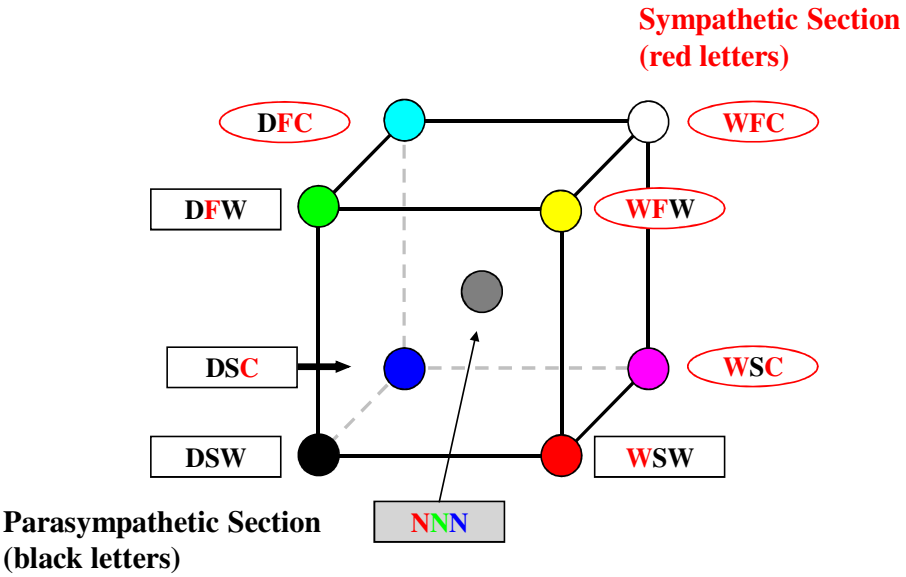
To conclude, using the <u>suitably adapted</u> **RGB Color Model** for the analysis of the VNS Equilibrium in **T.T.E. of VNS** has allowed to:

1) use only three parameters to describe all *possible functional states of the two sections, the Sympathetic and Parasympathetic, of the VNS;*
2) use a three-dimensional representation (the cube) to monitor *the state of dynamic balance between the two sections, the Sympathetic and Parasympathetic, of the VNS*;
3) use all the color graphics capabilities to visually represent in an innovative way the simultaneous and integrated trend of the three parameters;
4) give a single value of intensity at the simultaneous and integrated trends of the three parameters.

Using the Cube in the representation of state of dynamic equilibrium between the two sections of VNS

As has been amply explained in the paragraph "*The three parameters of the T.T.E. of VNS*", the GSR and the **THE** are physiological parameters under the ***exclusive tonic control of the Sympathetic Section of the VNS***, while the **HR** is an expression of balanced activation of the two sections, the Sympathetic and Parasympathetic. In the same paragraph has been made clear that the *trend of minor activation of the Sympathetic Section of the VNS does not correspond directly with the trend of maximum activation of the Parasympathetic Section*, but **it is not incorrect to use the trend of minor progressive tonic response of the Sympathetic Section to determine (even indirectly) the level of activation of the Parasympathetic Section**.
Taking into account these considerations in the **T.T.E. of VNS** the **Cube RGB color model** is used to evidence the individual contribution of the **GSR**, the **HR** and the **THE** in the formation of the **8 Principal Codes**. These codes describe briefly *all possible functional states of the VNS*.

In **Pct. 14** the codes are written in red and black letters. As we know, **the letters** are the initials of the specific **words** associated with physiological changes observed during the detection of each parameter. The **red letters** refer to all parameters conditioned by an INCREASE in the *Sympathetic Section,* while the **black letters**, except for the letter "**L**", refer to all persons with a DECREASE of the activation parameters of the *Sympathetic Section*. This *decrease* is interpreted as an indirect displacement of the balance in favor of the Parasympathetic Section. The letter "**S**" (Slow heart) indicates a reduction of **HR**, which is directly caused by the INCREASE of the activation of the Parasympathetic Section of the VNS.


Sympathetic Section
(red letters)
DFC
WFC
DFW
WFW
DSC
WSC
DSW
WSW
NNN
Parasympathetic Section
(black letters)

Pct. 14

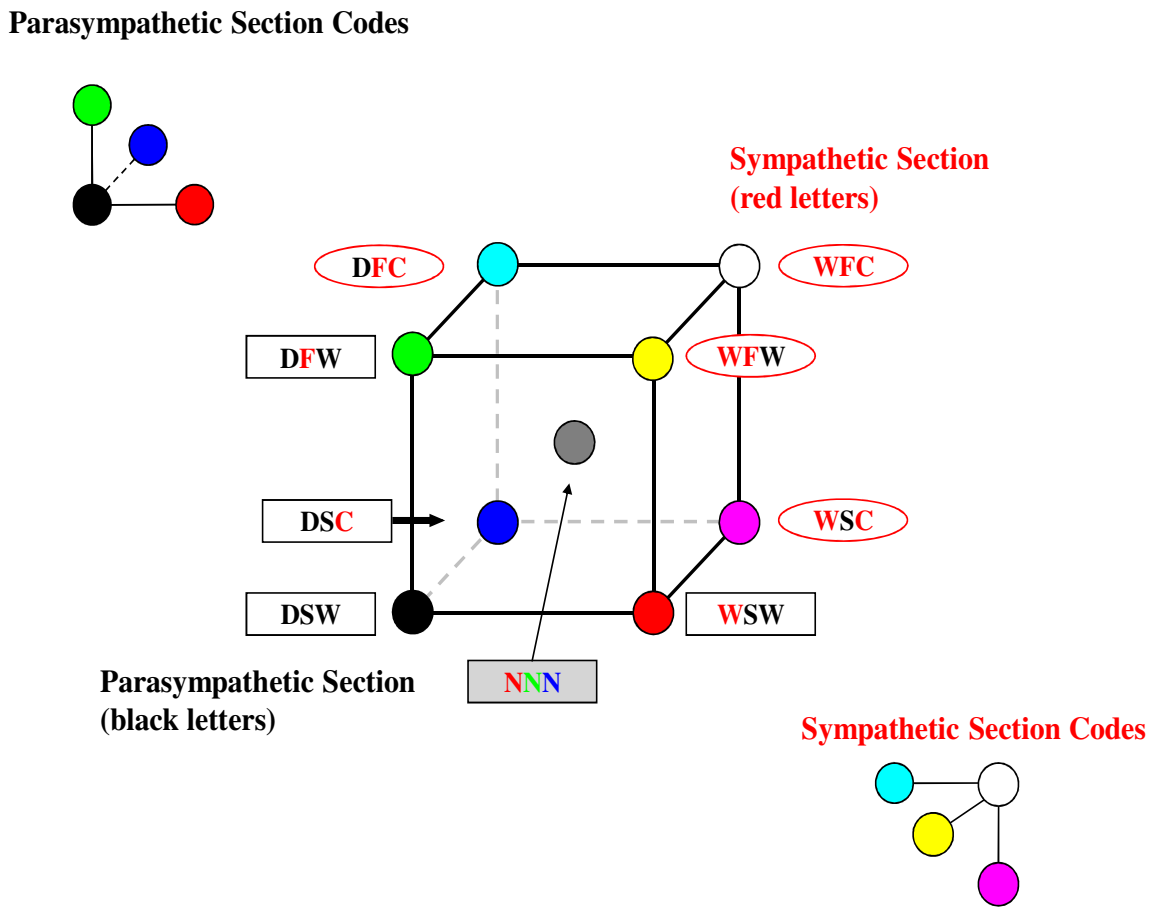
In **Pct. 15** are schematically summarized the **8 colors**, the **8 Principal Codes** (written in red and black letters to *distinguish analytically the activation code within each of the two sections of the VNS*) and their respective meanings used to briefly describe *all possible functional states of the VNS*.

COLORS	CODES	MEANING OF THE CODES		
	DSW	D = DRY HAND	S = SLOW HEART	W = WARM HAND
	DFW	D = DRY HAND	F = FAST HEART	W = WARM HAND
	DSC	D = DRY HAND	S = SLOW HEART	C = COLD HAND
	DFC	D = DRY HAND	F = FAST HEART	C = COLD HAND
	WSW	W = WET HAND	S = SLOW HEART	W = WARM HAND
	WFW	W = WET HAND	F = FAST HEART	W = WARM HAND
	WSC	W = WET HAND	S = SLOW HEART	C = COLD HAND
	WFC	W = WET HAND	F = FAST HEART	C = COLD HAND

Pct. 15

The **GSR**, **HR** and **THE** individually contribute to the formation of the codes. *Each code symbolizes the different modes of* ***simultaneous activation*** *of the three parameters*. From the **8 Principal Codes** a half of them (those with prevalence of red letters) are expressions of increased activation of the Sympathetic Section of the VNS, the other half (those with a prevalence of black letters) of its lower activation (and, indirectly, greater activation of the Parasympathetic Section).

In **Pct. 16**, the cube, the **8 colors** and the **8 Principal Codes** are used to represent the *state of dynamic equilibrium between the sections, Sympathetic and Parasympathetic, of the VNS.*



Pct. 16

In **Pct. 17** are schematically summarized the **8 colors,** the **8 Principal Codes** (written in red and black letters to *distinguish analytically the activation code within each of the two sections of the VNS*), their classification in relation to the section mainly involved (Parasympathetic or Sympathetic), and their respective meanings used to briefly describe *all possible functional states of VNS*.

COLORS	Parasympathetic Section CODES	MEANING OF THE CODES		
●	DSW	D = DRY HAND	S = SLOW HEART	W = WARM HAND
●	DFW	D = DRY HAND	F = FAST HEART	W = WARM HAND
●	DSC	D = DRY HAND	S = SLOW HEART	C = COLD HAND
●	WSW	W = WET HAND	S = SLOW HEART	W = WARM HAND
COLORS	**Sympathetic Section CODES**	**MEANING OF THE CODES**		
●	DFC	D = DRY HAND	F = FAST HEART	C = COLD HAND
●	WFW	W = WET HAND	F = FAST HEART	W = WARM HAND
●	WSC	W = WET HAND	S = SLOW HEART	C = COLD HAND
○	WFC	W = WET HAND	F = FAST HEART	C = COLD HAND

Pct. 17

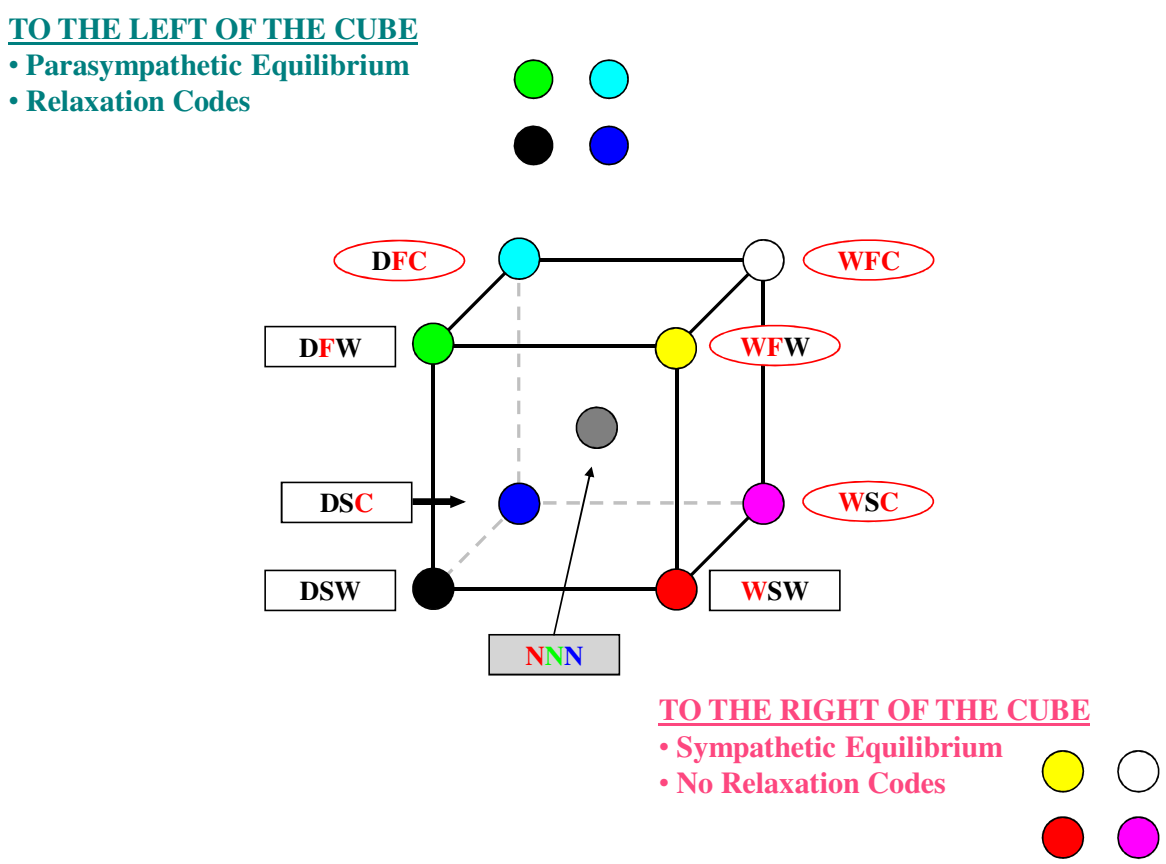
Muscle and Visceral relaxation and the Sympathetic/Parasympathetic Equilibrium of VNS

Muscle and visceral relaxation represent two conditions under which we feel quiet and relaxed. The physiological and emotional responses felt in a state of **muscular relaxation** are considered incompatible with anxiety, fear, anguish, conflict and psychophysical stress. Particularly, the *mental calm* is favored by the reduction of the contraction of the muscles of the eyes and the vocal tract (mouth muscles, tongue, larynx, etc.). Under conditions of deep muscle relaxation also the brain excitability is reduced and the **visceral relaxation** (the distension of the internal organs and the muscular walls of blood vessels) is facilitated. The *relaxation of voluntary muscles* reduces the mechanical compression of blood vessels and produces an indirect increase of their size, temperature device (**THE** ⬆), blood supply in an area of the body or throughout the body, reduced blood pressure and heart rate (**HR** ⬇). The **visceral relaxation** is dued to the direct activation of the *Parasympathetic Section of the VNS* or the indirect reduction of the *Sympathetic Section*. As has been said in "*The Vegetative Nervous System*", the *Parasympathetic Section* is involved in rest and sleep in all the states of quiet and energy recovery. This section works in an opposite manner to *Sympathetic Section*, which is activated by the emotions of fear and anger, escape behavior, and aggressive behavior during those many tasks which provide a high energy consumption. **So muscle and visceral relaxation enable to reduce the intensity of emotional reactions and behavior.** If these reactions are too intense, frequent and prolonged in time the capacity of reception and containment of the experience will seriously *weaken*. Learn to relax deeply reduces the level of anxiety and tension and one learns to perceive and recognize the signs of his body. Through a better understanding of these aspects can be produced a self-conscious behavior which tends to a better self-control and a greater adaptation to the circumstances and environmental requirements.

From the point of view of an objective measurement, **muscle relaxation** is detectable by electromyography (**EMG**). The **frontal muscle** is generally chosen as a muscle representing the level of muscle tension in the entire body. This practice is not always correct because it is possible that some muscles remain in tension or even present chronic contractures), even if the frontal muscle is relaxed. So an objective correct measurement should be realized using a greater number of muscle groups together. At the contrary, the objective measurement of **visceral relaxation** realized with the **T.T.E. of VNS** is always correct and reliable because it is based on analysis of simultaneous multiple parameters: the **GSR**, **HR** and **THE**. Essendo rappresentativo dell'equilibrio generale del SNV, l'analisi del trend simultaneo del **GSR**, della **FC** e la **THE** consente di rilevare con precisione lo **stato generale di rilassamento viscerale**. Representing the general VNS equilibrium, the analysis of the simultaneous trend of the **GSR**, **HR** and **THE** allows to detect precisely the general state of visceral relaxation. In the next paragraph we will see which of the **8 colors** and **8 Principal Codes** indicates the presence of **visceral relaxation**.

Using the Cube in the representation of the state of Visceral Relaxation

The **RGB** color model Cube, the **8 Colors** and **8 Principal Codes** can be used to represent the state of *Visceral* Relaxation. In **Pct. 18**, at the left of the cube, are evidenced the **4 Colors** and the **4 Principal Codes** that describe the **Visceral Relaxation**: DSW, DFW, DSC and DFC.



Pct. 18

These 4 Principal Codes are all characterized by a progressive decrease of the values of the **GSR** (⇩), evidenced by the letter "**D**" and physiologically determined by reducing the level of the Sympathetic System. Of these 4 Principal Codes, two of them, DSW and DFW, are characterized by a progressive *increase* (letter "**W**") of the values of the **THE** (⇧), while the other two, DSC and DFC, show their progressive *decrease* [letter "**C**" = **THE** (⇩)].

I propose to define **Visceral Relaxation Type I** the one characterized by the increase of the values of the **THE** (⬆) and **Visceral Relaxation Type II** the one distinguished by its decrease [**THE** (⬇)].

Generally the **Visceral Relaxation Type I** is characteristic for the first phase of relaxation, the one with *peripheral vasodilatation* and loss of body heat. **In the state of equilibrium predominantly Parasympathetic** (or reduced Sympathetic activation), the loss of body heat is a manifestation of the decrease in the level of defense against the external environment. This type of relaxation is generally accompanied by a significant reduction in the level of general muscular tension. **Visceral Relaxation Type II** is usually observed in the second phase of relaxation, the one with peripheral *vasoconstriction* and conservation of body heat. **In the state of equilibrium predominantly Parasympathetic** (or reduced Sympathetic activity), the conservation of body heat indicates a condition of savings and energy recovery (psycho-physiological profile typical of *deep sleep*). Note that as well the **Visceral Relaxation Type I** (DSW and DFW), as the **Visceral Relaxation Type II** (DSC and DFC) have both the letters "**S**" (**S**low Heart), and "**F**" (**F**ast Heart). This condition corresponds to the normal and necessary physiological oscillation in heart rate (S/F), which expresses the balance of the Parasympathetic and the Sympathetic Section of the VNS. This oscillation of the heart rate is always maintained, even when the general trend of the **HR** tends to have a higher frequency of the letter "**S**" (**S**low Heart) compared to the letter "**F**" (**F**ast Heart). This last occurrence is usually found in optimal conditions of **Visceral Relaxation** (both Type I and II) and is physiologically determined by the prevailing activation of the *Parasympathetic Section*.

In **Pct. 18**, at the right of the cube, the **4 Colours** and the **4 Principal Codes** that indicate the absence of visceral Relaxation: WSW, WFW, WSC and WFC are evidenced.

These 4 Principal Codes are all characterized by a progressive *increase* of the values of the **GSR** (⬆), shown by the letter "**W**" and physiologically determined by the activation of the *Sympathetic System*. Of these 4 Principal Codes, two of them, WSW and WFW, are characterized by a progressive *increase* ("**W**") of the values of the **THE** (⬆), while the other two, WSC and WFC, show a progressive *decrease* [(letter "**C**") = **THE** (⬇)]. The trend of the **THE** is important because, also in this case, it represents an index of opening or closing of the organism towards the environment. An **opening** and a willingness to interact with the environment by a part of the organism are associated with a trend of peripheral *vasodilatation* and an inevitable loss of body heat. **In the state of predominantly Sympathetic Equilibrium**, the loss of body heat is needed to prevent overheating of the organism involved in a job (see the principles of thermodynamics).

At the contrary, *peripheral vasoconstriction* and conservation of body heat are indicative of a **closure** of the organism in order to save energy and raise the defenses against the *external environment* as a result of a perceived threat to the psychophysical integrity. Note that, in human beings (and partly also in more developed animals), the threat may arise from the inside in the form of mental images, dreams, distressing thoughts and interpretations of sensory perceptions, proprioceptive as well as enteroceptive. Finally, with reference to the **HR**, for the same reasons given above regarding the **Visceral Relaxation Type I and II**, the pair of codes d WSW and WFW and the pair WSC and WFC contain both letters "**S**" (**S**low Heart) and "**F**" (**F**ast Heart).

In **Pct. 19** are schematically summarized **8 Colors** associated with the **8 Principal Codes** and with their respective meanings used to briefly describe *all possible functional states of the VNS*. The **8 Principal Codes** are divided into **4 Relaxation Codes** and **4 Non-Relaxation Codes**. From *the 4 Relaxation Codes*, two are with Heat Loss and two with Heat Conservation. All four of these codes are typical for the Parasympathetic Equilibrium (or a progressive reduction in the level of Sympathetic activation). From *the 4 Non-Relaxation Codes*, two are with Heat Loss and two with Heat Conservation. These last 4 Codes are typical for the Sympathetic Equilibrium.

COLORS	RELAXATION CODES with Heat Loss (Parasympathetic Equilibrium)	MEANING OF THE CODES		
	DSW	D = DRY HAND	S = SLOW HEART	W = WARM HAND
	DFW	D = DRY HAND	F = FAST HEART	W = WARM HAND
COLORS	RELAXATION CODES with Heat Conservation (Parasympathetic Equilibrium)	MEANING OF THE CODES		
	DSC	D = DRY HAND	S = SLOW HEART	C = COLD HAND
	DFC	D = DRY HAND	F = FAST HEART	C = COLD HAND
COLORS	NO RELAXATION CODES with Heat Loss (Sympathetic Equilibrium)	MEANING OF THE CODES		
	WSW	W = WET HAND	S = SLOW HEART	W = WARM HAND
	WFW	W = WET HAND	F = FAST HEART	W = WARM HAND
COLORS	NO RELAXATION CODES with Heat Conservation (Sympathetic Equilibrium)	MEANING OF THE CODES		
	WSC	W = WET HAND	S = SLOW HEART	C = COLD HAND
	WFC	W = WET HAND	F = FAST HEART	C = COLD HAND

In **Pct. 20**, at the left of the cube, the **2 Colors** and the **2 Principal Codes** that indicate the **Maximum Visceral Relaxation** are evidenced: DSW and DSC. These 2 Principal Codes are both characterized by the presence of a progressive *decrease* of the values of the **GSR** ( ) and of the **HR** ( ). Moreover, from these 2 Principal Codes, one of them, DSW, is characterized by the presence of a progressive *increase* (letter "**W**") of the values of the **THE** ( ), while the other one, DSC, shows their progressive *decrease* [letter "**C**" = **THE** ( )]. The increase and decrease of the **THE** tend to alternate in time as a manifestation of a natural rhythm, not defensively, recalling (also in a different time scale) the form and rate of breathing.
The progressive decrease of the values of the **GSR** and the **HR** trends shows a significant reduction of the Sympathetic activation and a parallel increase of the Parasympathetic activation.
This physiological condition, called the **Trophotropic Activitation**, is present during the accumulation of organic reserves, in energy conservation, during maintenance of normal baseline functions and in all conditions for rest, relaxation and sleep.

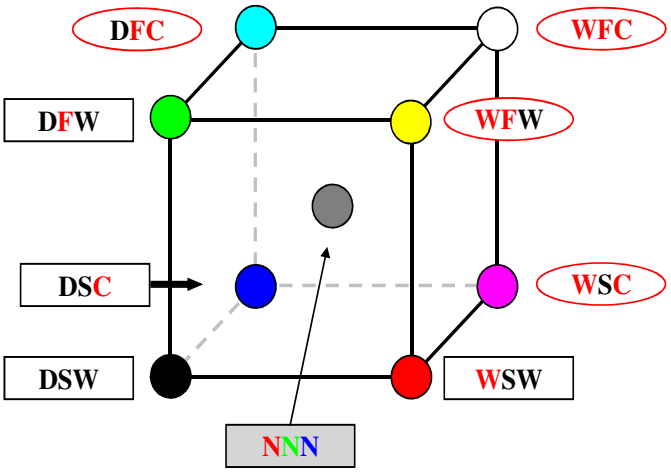
In **Pct. 20**, at the right of the cube, the **2 Colors** and the **2 Principal Codes** that indicate the **Maximum Non-Visceral Relaxation** are evidenced: WFW and WFC. These 2 Principal Codes are both characterized by the presence of a progressive *increase* of the values of the **GSR** ( ) and of the **HR** ( ). The increase of these values shows a significant trend of the increase of the Sympathetic Activation and a parallel decrease of the *Parasympathetic* Activation. This physiological condition, defined **Ergotropic Activation** is present during muscular activity, in conditions of energy consumption and use of bodily resources, in conditions of alarm and in the activation necessary to respond to emergencies and defense of the organism.

In this case, the progressive *increase* (letter "**W**") of the values of the **THE** ( ) in presence of the Principal Code WFW indicates the necessity of the organism to release into the external environment the excess of heat produced during a **Ergotropic Activation** at a high level of energy consumption (for instance during practicing a challenging exercise).

At the contrary, the progressive *decrease* (letter "**C**") of the **THE** ( ) in presence of the Principal Code WFC indicates an **Ergotropic Activation** predominantly defensive, typical for the condition of alarm or for the condition of physical effort at the limit of one's possibilities.

TO THE LEFT OF THE CUBE

- **Max Parasympathetic Activation**
- **Codes of Max Relaxation**
- **Max Trophotropic Activation**



TO THE RIGHT OF THE CUBE

- **Max Sympathetic Activation**
- **Codes of Max Non Relaxation**
- **Max Ergotropic Activation**

Pct. 20

In **Fig. 21** are schematically summarized **4 colors** associated with the **4 Principal Codes** and their respective meanings used to describe briefly the *functional states of the VNS*, typical for **Maximum Relaxation** (or **Trophotropic Activation**) and **Maximum Non-Relaxation** (or **Ergotropic Activation**). The 4 Principal Codes are divided in **2 Codes of Maximum Relaxation** and in **2 Codes of Maximum Non- Relaxation.** From these *2 Codes of Maximum Relaxation* one of them is for Heat Loss and the other one for Heat Conservation. Both of these codes are typical for the Parasympathetic Equilibrium (or for a progressive decrease of the Sympathetic Activation Level) and expression of a **Trophotropic Activation**. From the *2 Codes of Non- Relaxation*, one is for Heat Loss and the other one for Heat Conservation. These last 2 codes are typical for the Sympathetic Equilibrium and expression of an **Ergotropic Activation**.

COLORS	CODES OF MAX RELAXATION and of Max Parasympathetic (or Trophotropic) Activation	MEANING OF THE CODES		
●	DSW	D = DRY HAND	S = SLOW HEART	W = WARM HAND
●	DSC	D = DRY HAND	S = SLOW HEART	C = COLD HAND
COLORS	CODES OF MAX NON RELAXATION and of Max Sympathetic (or Ergotropic) Activation	MEANING OF THE CODES		
●	WFW	W = WET HAND	F = FAST HEART	W = WARM HAND
○	WFC	W = WET HAND	F = FAST HEART	C = COLD HAND

Pct. 21

Using the Cube in the representation of the Amygdala Activity and the state of dynamic equilibrium between the Anterior and Posterior section of the Hypothalamus

At the level of the **Hypothalamus** are carried out many actions of integration of visceral and somatic functions. The hypothalamus represents the most important anatomical structure of brain structures involved in the control of the vegetative life and also handles reactions on emergencies, organizing the viscero-motor reactions of their emotional states. **Physiologically, the activation of the Sympathetic Section of the VNS is associated with the involvement of the Posterior Hypothalamus.** Faced with a stimulus, an event or a perceived situation (consciously or unconsciously) as threatening, the A**mygdala** activates the **Posterior Hypothalamus**, which mobilizes the **pituitary-adrenocortical axis**. As explained in "*The three parameters of the T.T.E. of VNS*", the activation of this route follows the release of some hormones and neurotransmitters (particularly *adrenaline* and *noradrenaline*) that, further reinforcing the Amygdala Activity and the cycle of certain physiological reactions determined by the Posterior Hypothalamus, maintain high activity of the Sympathetic section of the VNS.

It has already been said that **the trend of maximum activation of the Sympathetic Section of the VNS** is always sufficiently and unambiguously described by:

[**I**ncrease of the del **GSR** (↑), **I**ncrease of the **HR** (↑), **D**ecrease of the **THE** (↓)].

In T.T.E. of VNS-language **the trend of maximum activation of the Sympathetic Section** is defined as follows:

1) **Increase** of the values of the **GSR** (↑) = **W**et Hands = Letter **W**;
2) **Increase** of the values of the **HR** (↑) = **F**ast Heart = Letter **F**;
3) **Decrease** of the values of the **THE** (↓) = **C**old Hands = Letter **C**.

So the code **WFC** represents **the trend of maximum activation of the Sympathetic Section of the VNS.** This ***specific response concomitant*** trend of the three parameters characterizes the ***Response on Defence or Alarm*** to stimuli, events or situations considered threatening by the subject for his physical and mental integrity.
The stimuli can be either *internal* [determined by thoughts, mental images, fantasies, hallucinations, feelings, significant physiological variations (e.g., decrease of the level of oxygen in the brain), etc..], or *external* (originating from sensory perception caused by actual variations of the stimuli present in the environment).

The psychophysiological profile opposite to the one described by Code **WFC**, i.e. **less activation of the Sympathetic Section of the VNS** (i.e. progressively greater activation of the *Parasympathetic Section*), is as follows:

[**D**ecrease of the **GSR** (⇩), **D**ecrease of the **HR** (⇩), **I**ncrease of the **THE** (⇧)].

In T.T.E. of VNS language **the trend of minimum activation of the Sympathetic Section** is defined as follows:

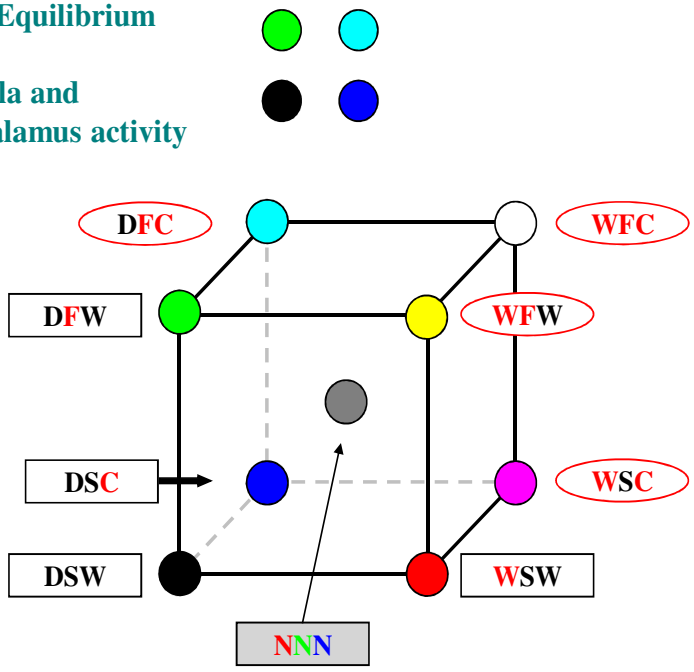
1) **Decrease** of the values of the **GSR** (⇩) = **D**ry Hands = Letter **D**;
2) **Decrease** of the values of the **HR** (⇩) = **S**low Heart = Letter **S**;
3) **Increase** of the values of the **THE** (⇧) = **W**arm Hands = Letter **W.**

The Code **DSW** represents **the trend of minimal activation of the Sympathetic Section of the VNS** (or the more progressive activation of the *Parasympathetic Section*) and together with the Principal Code DFW, describes the Relaxation of the ***Visceral Type I***.

In **Pct. 22**, in the right posterior part of the cube, are shown the **2 Colors** and the **2 Principal Codes** that describe respectively the ***Response on Defense /Alarm*** and the one of ***Anxious Apprehension*** associated with activation of the **Amygdala** and the **Posterior Hypothalamus**: **WFC** and **WSC**.
These two Principal Codes are characterized by a *progressive increase* of the values of the **GSR** (⇧), shown by the letter "**W**", and a *progressive decrease* of the **THE** (⇩), represented by the letter "**C**". The trend of these two parameters is physiological determined by the activation of the *Sympathetic System.* The **WSC** code differs from the code **WFC** only for as far as the response of the **HR** that, in the first one, tends to a progressive *decrease*. This difference in the trend of the **HR** is very important because it explains the temporal reduced duration of the ***Response on Defense/Alarm*** in confront of the ***Anxious Apprehension***. Indeed, the ***Anxious Apprehension*** can be defined as a ***prolonged Response on Defense/Alarm***. Physiological and psychological state of *uncertainty*, *unpredictability* and *precariousness* associated with Anxious Apprehension may be prolonged in time just because in the overall heart balance the **HR** tends to be more represented by the letter "**S**" (**S**low heart) than by the letter "**F**" (**F**ast heart).
If this overall balance was reversed ("**F**">"**S**"), i.e. **if the physiological state described by the code WFC would continue over time**, the experience for the subject would assume the characteristics of emotional fear (or terror) typical for a *panic attack*. This can, for its nature, only have a limited duration in time. In this context, from the physiological point of view, the ***Anxious Apprehension*** can be considered as an inevitable attempt to contain [limiting cardiac activity ("**S**">"**F**")] a continuous and pathological response to panic.

TO THE LEFT OF THE CUBE

- **Parasympathetic Equilibrium**
- **Relaxation Codes**
- **Decrease Amygdala and Posterior Hypothalamus activity**



RIGHT POSTERIOR PART OF THE CUBE

- **Sympathetic Equilibrium**
- **Alarm / Defense /Anxiety**
- **Increase Amygdala and Posterior Hypothalamus activity**

Pct. 22

In **Fig. 22**, at the left of the cube, the **4 Colors** and the **4 Principal Codes** that describe the **Visceral Relaxation Type I** (DSW, DFW) and **Type II** (DSC and DFC), are evidenced.
As we know, the trend of these 4 Principal Codes is characterized by a progressive *decrease* of the values of the **GSR** (↓). This condition is already in itself incompatible with the activation of the Sympathetic System and the brain structures functionally associated with it, particularly the **Amygdala** and the **Posterior Hypothalamus**.

In **Fig. 23** are schematically summarized the **4 colors** associated with the **4 correspondent Principal Codes of the Visceral Relaxation Type I and II**, the **2 colors** and the **2 Principal Codes** that describe the ***Response on Defense / Alarm / Anxious Apprehension*** and at the end the meanings of all these codes.

COLORS	CODES OF RELAXATION TYPE I Decrease Amygdala and Posterior Hypothalamus Activity (parasympathetic Equilibrium)	MEANING OF THE CODES		
●	DSW	D = DRY HAND	S = SLOW HEART	W = WARM HAND
●	DFW	D = DRY HAND	F = FAST HEART	W = WARM HAND
COLORS	CODES OF RELAXATION TYPE II Decrease Amygdala and Posterior Hypothalamus Activity (parasympathetic Equilibrium)	MEANING OF THE CODES		
●	DSC	D = DRY HAND	S = SLOW HEART	C = COLD HAND
●	DFC	D = DRY HAND	F = FAST HEART	C = COLD HAND
COLORS	CODES OF ALARM / DEFENSE / ANXIETY Increase Amygdala and Posterior Hypothalamus Activity (Sympathetic Equilibrium)	MEANING OF THE CODES		
●	WSC	W = WET HAND	S = SLOW HEART	C = COLD HAND
○	WFC	W = WET HAND	F = FAST HEART	C = COLD HAND

Pct. 23

Like any brain structure, also the Hypothalamus has a spatial structure which corresponds to different physiological functions. For the analysis of the dynamic equilibrium of the VNS, the functional difference between the **Anterior** and **Posterior** section of the **Hypothalamus** plays an important role. In the scientific literature is well established that the **Anterior** section is involved in *rest* and *visceral relaxation*, while the Posterior section is activated in *response to situations of emergency, warning and defense*.

In **Fig. 24**, an hypothesis of a functional map of the **Anterior** and **Posterior** section of the **Hypothalamus** and of the **Preoptic Hypothalamus** activity is proposed. The frame of reference is the cube, and the functioning of these areas of the H*ypothalamus* is described by the **8 Principal Codes**, which are the result of the simultaneously activity of the three parameters (**GSR**, **HR** and **THE**).

At the left anterior part of the cube, the Colors and Principal Codes that describe the **Visceral Relaxation Type I** (DSW, DFW) are evidenced, which is determined by the increase of the **Anterior Hypothalamus** activity.

At the right posterior part of the cube, the Colors and Principal Codes that describe the ***Response on Defense/Alarm*** and the ***Anxious Apprehension*** (WFC and WSC) are evidenced, caused by the increase of the **Posterior Hypothalamus** activity.

At the right anterior part of the cube, the Colors and Principal Codes that describe an **Ergotrophic Activation at a high level of energy consumption** (WSW, WFW) are evidenced , determined by the prevailing *increase* of the activity of the **Preoptic Hypothalamus Area.**

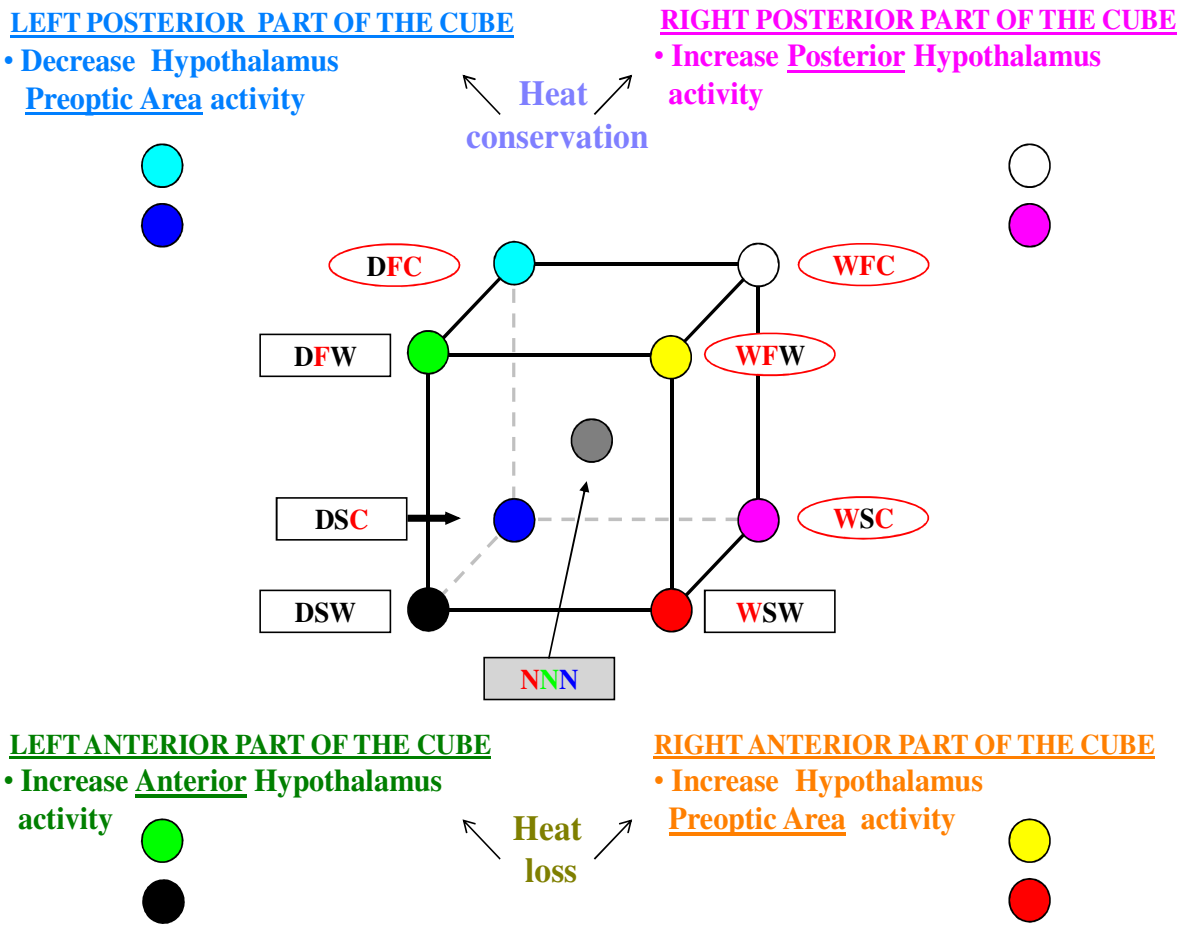
At the left posterior part of the cube, the Colors and Principal Codes that describe the **Visceral Relaxation Type II** (DSC and DFC) are evidenced, determined by the prevailing *decrease* of the **Preoptic Hypothalamus Area.**

The increase and decrease of the **Preoptic Hypothalamus Area** are indirectly deducted from the trend of the **THE** in relation to the other two parameters. As we have seen, the **Preoptic Hypothalamus Area** controls the body temperature. An *increase* of the **Preoptic Area** activity is associated with **heat loss** through a consistent *peripheral vasodilatation* [**THE** (↑) = Letter "**W**"] and a significant *sweating* [which can also involve the **GSR** (↑) = Letter "**W**"].

The physiological purpose is to **disperse heat into the outside, produced by** "work" of the organism (in order to prevent that the temperature of cells and internal organs can **rise** dangerously.) This physiological profile is typical for the Ergotrophic Activation at a high level of energy consumption (WSW, WFW). At the contrary, an *increase* of the **Preoptic Area** is associated with **heat conservation** through a consistent *peripheral vasoconstriction* [**THE** (↓) = Letter "**C**"] and reduced *sweating* [which can involve also the **GSR** (↓) = Letter "**W**"]. The physiological purpose is **not to disperse heat into the outside** (to prevent that the temperature of the cells and internal organs can **reduce** dangerously) and at the same time **save and conserve energy**. This

physiological profile is typical for the **Visceral Relaxation Type II** (DSC e DFC) found during *deep sleep* and a few meditation exercises.

In **Fig. 24** the anterior part of the cube (right and left) presents 4 Colors and 4 Principal Codes that describe the **Heat Loss** (DSW, DFW, WSW and WFW) determined by the *increase* of the **Anterior Hypothalamus** activity (DSW, DFW) or by the prevailing **Preoptic Hypothalamus Area** (WSW, WFW).
At the contrary, the posterior part of the cube (right and left) presents 4 Colors and 4 Principal Codes that describe the **Heat Conservation** (DSC, DFC, WFC and WSC) determined by the *increase* of the **Posterior Hypothalamus** activity (WFC e WSC) or by the prevailing *decrease* of the **Preoptic Hypothalamus Area** (DSC e DFC).



Pct. 24

In **Fig. 25** are schematically summarized the **8 colors**, the **8 Principal Codes**, their association with the **Loss** and the **Conservation** of **Heat** and with the activation of the **Anterior Hypothalamus** (DSW and DFW), the **Posterior Hypothalamus** (WFC and WSC), the **Preoptic Area** (WSW, WFW, DSC and DFC) and their respective meanings used to describe briefly all *the functional states of the VNS.*

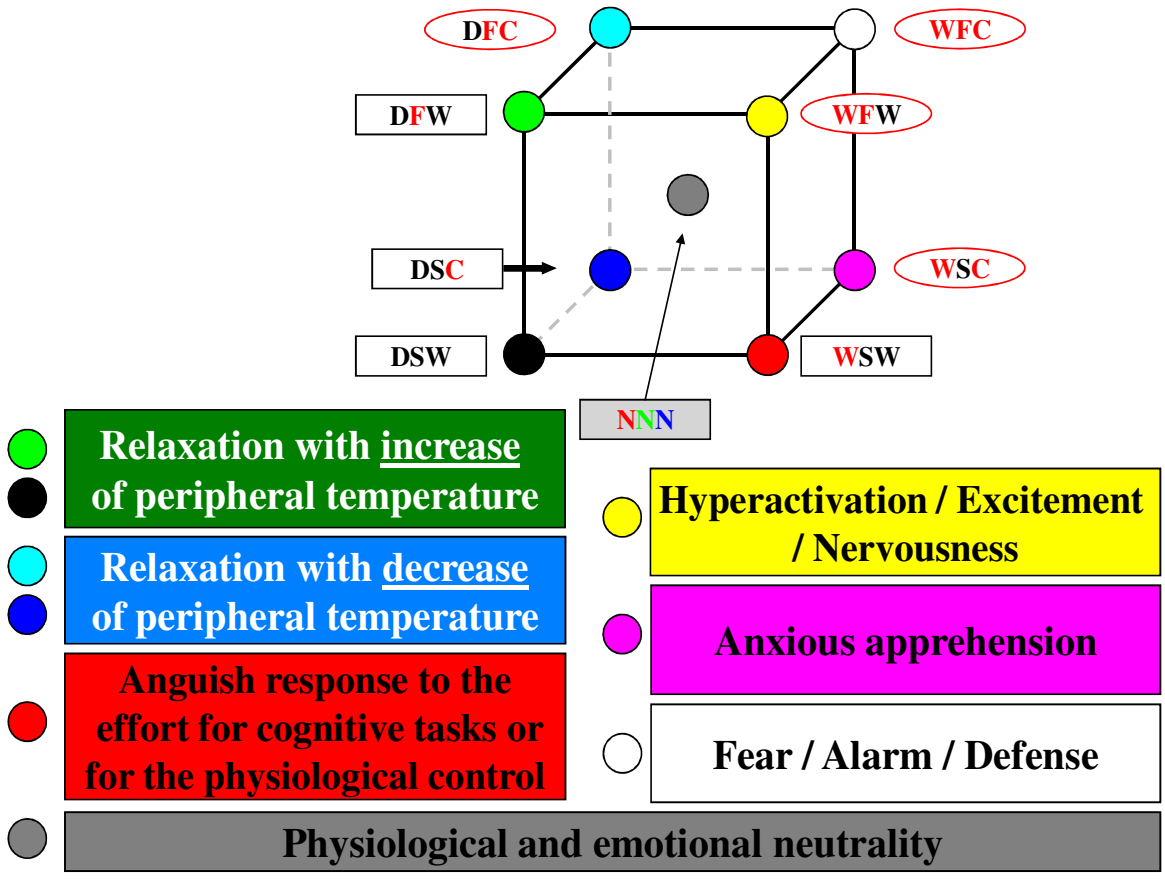
COLORS	CODES OF *INCREASE* ANTERIOR HYPOTHALAMUS ACTIVITY (Heat Loss)	MEANING OF THE CODES		
●	**DSW**	**D = DRY HAND**	**S = SLOW HEART**	**W = WARM HAND**
●	**DFW**	**D = DRY HAND**	**F = FAST HEART**	**W = WARM HAND**
COLORS	**CODES OF *INCREASE* HYPOTHALAMUS PREOPTIC AREA ACTIVITY (Heat Loss)**	**MEANING OF THE CODES**		
●	**WSW**	**W = WET HAND**	**S = SLOW HEART**	**W = WARM HAND**
●	**WFW**	**W = WET HAND**	**F = FAST HEART**	**W = WARM HAND**
COLORS	**CODES OF *DECREASE* HYPOTHALAMUS PREOPTIC AREA ACTIVITY (Heat Conservation)**	**MEANING OF THE CODES**		
●	**DSC**	**D = DRY HAND**	**S = SLOW HEART**	**C = COLD HAND**
●	**DFC**	**D = DRY HAND**	**F = FAST HEART**	**C = COLD HAND**
COLORS	**CODES OF *INCREASE* POSTERIOR HYPOTHALAMUS ACTIVITY (Heat Conservation)**	**MEANING OF THE CODES**		
●	**WSC**	**W = WET HAND**	**S = SLOW HEART**	**C = COLD HAND**
○	**WFC**	**W = WET HAND**	**F = FAST HEART**	**C = COLD HAND**

Pct. 25

Emotional states correlated to the physiological responses corresponding to the 8 Principal Codes

The 8 Principal Codes are a clear and effective way to describe the trend of the **GSR**, the **HR** and the **THE** and to evaluate the state of dynamic equilibrium of the Sympathetic and the Parasympathetic Section of the VNS. From the clinical point of view it is important to identify which *emotional states are correlated to physiological responses corresponding to the 8 Principal Codes*. Ten years of clinical experience applying to the different case studies the T.T.E. of VNS and its computer program, have led to the identification of **6 major Psychophysiological Profiles** ***relevant to the emotional point of view*** and one ***relevant to the physiological and emotional neutrality*****.**

In **Pct. 26** are summarized the ***emotional states correlated*** **to the physiological responses corresponding to the 8 Principal Codes** that describe the main trends of the three parameters of the T.T.E. of VNS. From the 8 Principal Codes were obtained **6 Psychophysiological Profiles** ***relevant to the emotional point of view*** and one ***relevant to the physiological and emotional neutrality***.



Pct. 26

The **6 Psychophysiological** profiles summarized in **Pct. 26** and ***relevant from the emotional point of view*** are:

1) **Relaxation with increase of peripheral temperature** (or *Visceral Relaxation type I*). Principal Codes that describe this Relaxation are **DSW** (Black) and **DFW** (Green). The emotional state associated with these codes is described as a feeling of quietness, of pleasant and conscious neglect, of heat and muscle relaxation;

2) **Relaxation with decrease of peripheral temperature** (or *Visceral Relaxation type II*). Principal Codes that describe this Relaxation are **DSC** (Blue) and **DFC** (Cian). The emotional state associated with these codes is described as a feeling of quietness, of pleasant and deep relaxation, of a significant muscle relaxation. This profile is typical for some states of meditation and dreamless sleep;

3) **Anxiety effort to cognitive tasks or physiological control**. The Principal Code that describes this psychophysiological state is **WSW** (Red)**.** This code is typically found during the execution of cognitive tasks or physiological binding that were not yet fully seen (for example, it is easily detectable during the first learning sessions of *voluntary control* of some physiological parameters)**.** The emotional state associated with this code is described as a state of anxiety (especially felt in *the chest and the abdominal),* of stress and fatigue (*perceived also in conditions of absolute immobility*) for the task adhesion. This state of anxiety doesn't always mean to be unpleasant, because it can be experienced even pleasantly (for example, during the plateau phase in sexual intercourse or in the effort to delay the ejaculatory response). A good hypothesis is that the state of anxiety (the word anxiety is etymologically linked to chest tightness) can be determined by the respiratory rate that the subject imposes itself and to which it is used a little or not at all) to control the **HR** [ = prevalence of the letter "**S**" (Slow heart) compared 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) compared to the letter **"D**" (**D**ry hands)] is indicative for the *work* that the organism accomplishes to perform the task and to maintain control. The increase of the **THE** (), proved by the prevailing letter **"W**" (**W**arm hand) compared to the letter **"C**" (**C**old hands), confirms the need to release to the outside the *heat* produced by the *work* accomplished to perform the task;

4) **Hyperactivation / Excitement / Nervousness**. The Principal-Code that describes this psychophysiological state is **WFW** (Yellow). This code is generally found along with the code **WSW** while performing cognitive tasks or physiological binding; however, it may also occur in isolation, as an expression of *an effort* (cognitive or physiological) *brief but*

intense (for example, an acceleration during a race or the pre-orgasmic and orgasmic phase during intercourse). For example, the codes **WSW** e **WFW** appear together in specific circumstances during **hyperventilation**, but take on different physiological meanings [see website www.ttesystems.eu, paragraph "T.T.E. of VNS", article *"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"*]. The emotional state associated with this code is described as a state of exitement (especially felt in the *chest*) that can be connoted emotionally in a positive way (for example during sexual intercourse) or negative (for example in cardiac hyperactivity preceding a panic attack). Also in this case, the relationship between respiration and heart activity is significant. The excited respiratory rate causes ***shortness of breath*** (thoracic breathing) and is associated with a remarkable increase of the **HR** [⇧ = prevalence of the letter "**F**" (**F**ast heart) compared to the letter "**S**" (**S**low heart)]. L'incremento del **GSR** [(⇧) = prevalence of the letter "**W**" (**W**et hands) compared to the letter "**D**" (Dry hands)] is indicative for the physiological work associated with the state of excitement. As for the code **WSW**, the increase of the **THE** (⇧) is indicative for the need to release to the outside the excess of heat. Regarding the **THE** it's essential to remember that while the **peripheral vasoconstriction** [**THE** (⇩)] is one of the ways in which the VNS prepares the organism to fight, to flee or to retire with energy recovery, the **peripheral vasodilatation** [**THE** (⇧)] further points to the organisms ability to "**support**" quite properly the experience, to be "**part of it**", to invest energies, also and despite of the effort and / or high energy consumption. Compared with energy consumption, the code **WFW** (typical for the Sympathetic activation) is, along with the code **WFC** and even more than this last one, expression of the **Maximum Ergotropic Activation**;

5) **Anxious apprehension.** The Principal-code that describes this psychophysiological state is **WSC** (Magenta). The emotional state associated with this code is the one characterized by the state of anxiety that accompanies the uncertainty about the outcome of a positively expected or the fear for a negatively expected event (*performance anxiety*). It has already been said that the ***Anxious apprehension*** can be defined as a ***Response of Defense/Alarm*** (code **WFC**) ***prolonged in time***. The emotional state associated with ***Anxious apprehension*** can be prolonged in time only because in the overall balance of the heart activity **HR** (⇩) it tends to be more represented by the letter "**S**" (**S**low heart) that the letter "**F**" (**F**ast heart). If this overall balance should be inverted ("**F**">"**S**"), the experience for the subject would assume the characteristics of emotional fear (or terror) typical of a *panic attack* (code **WFC**). The ***Anxious apprehension*** can therefore be considerated as an

inevitable attempt to contain [limiting cardiac activity ("**S**"> "**F**")] a sustained pathological panic response. The increase of the **GSR** (↑) is indicative for the physiological work needed to contain the physical sensations associated to the state of uncertainty, while the **peripheral vasoconstriction** [**THE** (↓)] indicates the *state of defense* in which the organism finds itself trying to support a rather unpleasant emotional experience;

6) **Fear / Alarm / Defense**. The Principal-code that describes this psychophysiological state is **WFC** (White). This code describes the **trend of maximum activation of the Sympathetic Section of the VNS** and is one of the 2 codes (along with the code **WFW**) of **Maximum Ergotropic Activation**:

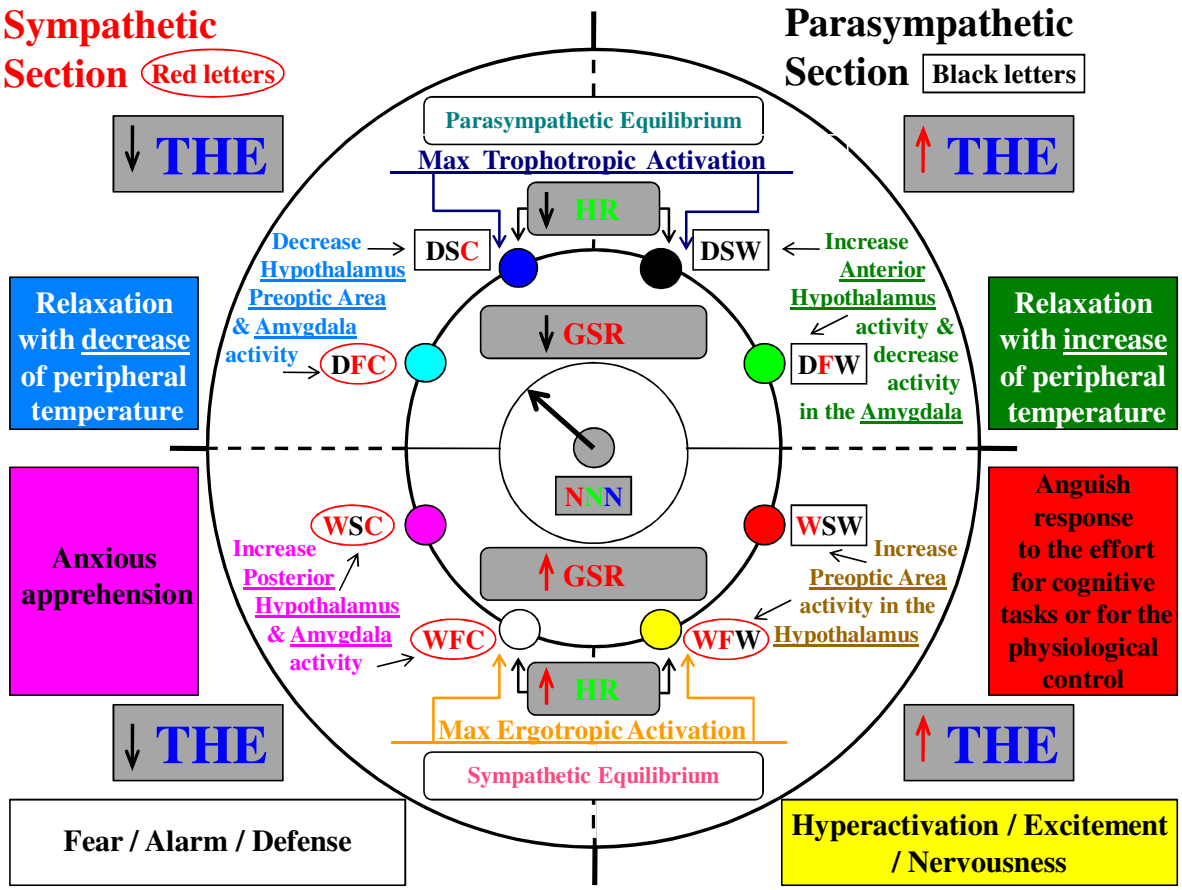
[**I**ncrease of the del **GSR** (↑), **I**ncrease of the **HR** (↑), **D**ecrease of the **THE** (↓)].

The emotional state associated with this code is the one of fear, that can reach the intensity of the terror felt during a *panic attack*. Physiologically, the emotion of *fear*, particularly of *terror*, can only have a limited duration in time; indeed, during this emotional experience, the **HR** (↑) tends to be represented more by the letter "**F**" (**F**ast heart) then by the letter "**S**" (**S**low heart). The physiological condition "**F**">"**S**" is sustainable for a certain time only if associated with **peripheral vasodilatation** [**THE** (↑)] highlights again the organism's ability to "support" quite adequately the experience despite the effort [(also indicated by the increase of the **GSR** (↑) values)] and/or the high energy consumption. At the contrary, in conditions of *Fear / Alarm / Defense*, the **peripheral vasoconstriction** [**THE** (↓)] indicates the *state of defense* in which the organism finds itself trying to support a rather unpleasant emotional experience. A high level of **peripheral vasoconstriction** causes the increase of *Blood Pressure* (hypertension) that, to compensate, contributes significantly (along with other important physiological reactions) to the transition of the condition "**F**">"**S**" (of the code **WFC**) and "**L**" >" **V**" (of code **WSC** that describes the *Anxious apprehension*);

7) **Physiological and emotional neutrality**. The Principal Code that describes this psychophysiological state is **NNN** (Grey). This code indicates the *absence of changes in the measured parameters* (physiological neutrality). It's an unusual code and detected only in particular circumstances (for example during prolonged relaxation exercises and/or meditation exercises or during dreamless sleep). To this code is correlated a state of emotional neutrality of which one hardly is aware.

Single image to summarize the main features of the T.T. E. del VNS

To summarize and make a comprehensible overview of the multiple interactions between the concepts and various aspects that are the basis of the T.T.E. of VNS you can find in **Pct. 27** a clarifying summarizing image. In this picture are represented the **8 Principal Codes** that describe the trend of the three parameters of the T.T.E. of VNS and their respective **8 colors**. For each code the constitutive letters are **Black**, to indicate an activation of the *Parasympathetic Section* or a reduced activation of the *Sympathetic Section*, or **Red**, to indicate an activation of the *Sympathetic Section*. At the centre of the picture you find the **code NNN**, indicative for the *physiological and emotional neutrality*. The picture presents the **three selected parameters** (**GSR**, **HR** and **THE**) and their respective trends are defined using **black arrows** pointing *downwards* (indicating a decrease of the parameter values) or **red arrows** pointing upwards (indicating an increase of the parameter values). At the top of the represented circle are organized the **4 Codes** (DSW, DFW, DSC and DFC) that describe the **Parasympathetic Equilibrium**, while in its lower part are represented those (WSW, WFW, WSC and WFC) that describe the **Sympathetic Equilibrium**. Also at the top of the circle are shown the **2 Codes** (DSW and DSC) that indicate the **Maximum Trophotropic Activation,** while in its lower part are represented those (WFW and WFC) that appear in conditions of **Maximum Ergotropic Activation**. Inside the circle are shown the relations between the **8 Codes** and the activation of the **Amygdala** and of the various **Areas of the Hypothalamus**, while outside the circle the emotional states correlated to the physiological responses corresponding to **8 Codes** are shown. The position and the movement of the black arrow at the inside of the circle originating from the **code NNN**, indicate directly and in real time the simultaneous activity of the ***three selected parameters*** (**GSR**, **HR** and **THE**), the activated codes at any time and their wider physiological and emotional meanings. Finally, the positions and the movements of the black arrow can indicate all the *significant transitions* occurring between the different codes (determined by the variation of one, two or all three parameters at the same time). Among these *significant transitions* is very important from the psychophysiological point of view the one between the code **WFW** and **WFC**, i.e. the transition from a physiological and emotional state that may be pleasant as well (code **WFW**) into a normally associated (code **WFC**) to an little pleasantly emotion like **fear** [in this regard see website www.ttesystems.eu, section "T.T.E. of VNS", paragraph "*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*"].


Sympathetic Section
Red letters
Parasympathetic Section
Black letters
↓ THE
↑ THE
Parasympathetic Equilibrium
Max Trophotropic Activation
HR
Decrease Hypothalamus Preoptic Area & Amygdala activity
DSC
DSW
Increase Anterior Hypothalamus activity & decrease activity in the Amygdala
Relaxation with decrease of peripheral temperature
GSR
DFC
DFW
Relaxation with increase of peripheral temperature
NNN
Anxious apprehension
WSC
WSW
Anguish response to the effort for cognitive tasks or for the physiological control
Increase Posterior Hypothalamus & Amygdala activity
GSR
Increase Preoptic Area activity in the Hypothalamus
WFC
WFW
HR
Max Ergotropic Activation
Sympathetic Equilibrium
↓ THE
↑ THE
Fear / Alarm / Defense
Hyperactivation / Excitement / Nervousness

Pct. 27

Conclusions

The aim of this study was to present the theoretical fundamental principles related to the **T.T.E. of VNS**. The innovative aspects of this *theory* and its *method* of computerized processing of data collected through peripheral biofeedback, should now appear indisputable. With the **T.T.E. of VNS** *it is effectively possible to observe, analyze, control and modify in real time, the state of dynamic balance between the two sections, Sympathetic and Parasympathetic, of the Vegetative Nervous System.* For a better comprehension of the potentiality in the clinical applications of the theory and the method, however, it is necessary to refer to other work already published on the website www.ttesystems.eu (see "*The Peripheral Biofeedback and the Trichromatic Theory of Equilibrium of the Vegetative Nervous System " and "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*"). Another clinical work in which will be used the **T.T.E. of VNS** will be published in the second half of 2011, in which will be presented the ***Long-Term Depression and Reprocessing of fearful and traumatic memories*** **(LTDR**), a new specialist procedure of psychotherapeutic treatment of traumatic and fearful memories, that can be autonomously applied or easily inserted in other psychotherapeutic protocols (Flooding, Systematic Desensitization, EMDR, Hypnotic and Imagination Techniques, Experimental Techniques of the Schema Therapy, Relaxation Techniques, Mindfulness and other Techniques of Meditation, etc.) strengthening enormously their already proved effectiveness. This procedure will be the subject of an oral presentation in October 2010 in Milan at the forthcoming ***40th Congress of the European Association for Behavioural and Cognitive Therapies*** (***EABCT***) entitled: *The LTDR: a new specialist procedure of psychotherapeutic treatment of fearful and traumatic memories with the Peripheral Biofeedback and the Trichromatic Theory of Equilibrium of the Vegetative Nervous System.* The same argument will be presented, more extended and detailed, in a workshop to be held in Germany, Munich, at the **15th Annual Meeting of the European Foundation of Biofeedback** (BFE). Before concluding, however, I wish to remind you that the **T.T.E. del SNV** is just one of the possible applications of the more general **Trichromatic Theory of Equilibrium of Systems** (**T.T.E.S.**). In the coming months, on the website www.ttesystems.eu (section "T.T.E.S.") will be published the article "*A universal vision of reality: the Trichromatic Theory Trichromatic of Equilibrium of Systems*", in which the aspects that allow us to use the **T.T.E.S.** for the analysis of other systems through the section TEST ONLINE and the APPLICATION of the website www.ttesystems.eu. will be deepened.

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