EMOTION LOGIC & EDP WHITE PAPER

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1. BEFORE WE BEGIN

There are diversified academic views pertaining to the exact contribution of non-verbal communication, and the significance of emotion expression for the other party to capture one's message - but there is no doubt that the nature of the emotional reaction is significant to the understanding of behavior and decision-making processes.

The general definition of "emotion expression" relates to facial expression, body language and tone of voice, with varying ratios based on the type of settings tested. Emotional expression by tone of voice is typically considered as a highly controlled expression, and in fact, the better one's acting skills are, the better he can convey his emotions and act out different emotional settings to his listeners. While different applications may be considered where such acting skills are quantified and measured, will these expressions have any importance to an application that intends to evaluate the genuine emotion state? This type of analysis will have to go deeper into the voice structures, seeking for the lost cues and the true emotional colors.

This white paper discusses the LVA (Layered Voice Analysis) by its principle methods of operations that can be publicly revealed, and different applications where genuine emotion analysis can be applied across different industries.

1.1 DOCUMENT'S MAIN PURPOSE

This document provides initial guidance to those making their first steps into the Genuine Emotion through Voice Analysis sphere, and includes description of the features, capabilities and technical functionality of the LVA technology and the EDP (Emotional Detection and Personality) platform.

2. LVA DESCRIPTION

2.1 BACKGROUND OF VOICE ANALYSIS

Voice analysis is an everyday process, performed by almost everyone, and in fact relates to 3 very distinct disciplines:

Who is the person speaking?

Each of us have some unique characteristics in our voice. This field is known as "voice-print" analysis.

What is being said?

Understanding the textual message being delivered. This is known as "speech-to-text".

How do we feel?

What is the emotional experience we currently feel as we speak? As you will soon see, this, and only this, is what LVA technology is all about.

While all these disciplines have tremendous value in any interaction and especially in modern technologies, Emotion Logic focus only on the third discipline, the one that was least explored and was the hardest to make progress as it lacked any previous scientific background.

Therefore, a theoretical background was developed and a process was built from scratch.

In every interaction we have with others, almost all of us, consciously or not, pick up some non-verbal cues from the other speaker. We evaluate their state of mind, their emotional reaction, their honesty - and indeed, when we communicate with others, we ourselves often voluntarily change our tone of voice to **reflect a state of mind.**

But now – think about this:

How often do we let our voice **reveal our true feelings?**

How often do we **use our voice to express a fabricated feeling** that masks a true feeling?

How often do we **try to control our voice, so it will not reveal our genuine emotions?**

And **when do we really care if our emotions are properly revealed** or hidden?

Traditional voice analysis (Phonetics) deals with the cues we can hear - that are by nature, more pronounced and loud, expressed over time frames that are greater than 10 Milliseconds (10 ms). LVA is unique in its approach, and uses the power of today's sound cards to listen deeper into the voice, to identify the traces of its uncontrolled properties; those that reveal the genuine inner reaction - the true sensations and feelings one experiences while verbalizing thoughts. These sensations are present in the time frames that are below 10 ms, and new types of measurements had to be invented to capture and compute these indications. These values form the foundation of the LVA technology, and together with a set of baseline measurements, will serve us in every emotional analysis process LVA performs.

2.2 BASIC DEFINITIONS AND LVA'S VOCABULARY

01 Voice Segment

A segment of voice ranging in length from 0.3 seconds to 1, 2 or 3 seconds, according to user specifications and the system's internal logic. The segment is usually a logical speech block, containing a word or a part of sentence, however, this is not always the case and sometimes long sentences will be separated into different voice segments.

02 Emotional Signature

A string of numbers that summarizes the emotional activity detected in a specific voice segment by the core component. The Emotional Signature contains all of the relevant data that will be used by external learning engines.

03 Objective parameters

Basic emotion values that are calculated and normalized to scale and are relative to known standard ranges of the global population.

04 Basic bio-markers

A set of 151 proprietary voice bio-markers from which the different emotions are calculated.

05 Subjective parameters

Basic emotion values that are calculated as deviations from the analyzed individual's baseline state ('calibration' values).

06 BG Level

Setting of the expected and normal background noise level. The core component uses this value as part of the voice stream segmentation logic.

2.3 FOUR BASIC SENSATIONS

At the basis of the LVA technology, we focus on 3 "Sensations". These are very fundamental feelings one would experience without the intervention of any logical activity and are considered instinctive: Stress, Excitement and Confusion. We also pick up one fundamental reaction, "Energy" that in various levels is the basis of several key emotional states.

01 We defined **Energy** as the internal power that drives us forward. Energy is a basic element in **"FOUR BASIC SENSATIONS"** as well as **"Happy"** emotional states, and in very high levels is also indicative of violence and furious anger. Very low values will indicate tiredness.

02 **Stress** is clinically defined as the body's reaction to a threat. The Amygdala part in our brain identifies a potential risk and sends an alarm to the body to prepare for action. The ancient brain will assume control and transition the body into "survival mode". In essence, the sole desire of the body at this point is NOT TO BE where the threat is.

03 **Excitement** is the exact opposite of stress. It is the brain's positive reaction pushing the body to move forward, towards the existing stimuli due to positive expectations.

04 **Cognitive Stress** or cognitive dissonance is a conflict of two or more logical processes running simultaneously acting against one another.

LVA process streams of data in real-time or from pre-recorded material in the exact same manner, and it is extremely resource conservative.

All these sensations have similar effects on the body's preparation and many psycho-physiologists claimed they are in fact one – but voice analysis bio-markers associated with each sensation can be measured independently and are very different.

PLEASE NOTE! LVA's technology is designed to detect subtle and uncontrolled voice properties, indicative of the speaker's GENUINE emotional state. Actor's voices and fake sounds will not trigger the expected/acted reaction.

2.4 A WORD OF CAUTION

Voice analysis, by its nature, is a very sensitive measurement. The audio quality is easily influenced by the level of input and noise interferences, the quality of equipment, compression methods used and external stimuli the tested subjects experience as they speak. Taking all these limitations into account, what LVA is still able to extract from almost every voice signal is really an unexpected wealth of information – but common sense and attention to details must be applied in every step of the analysis process.

3. LVA TECHNOLOGY

LVA was originally designed as an investigation aid and ultimately was made to seek indications for truthfulness and falsehood. While these purposes are still served, over the years it was discovered that LVA can do so much more. LVA is the result of 23 years of research as for today.

LVA uses several processes one after the other to perform its mission:

1. **Optimization & normalization** of the input audio data.

2. Selection and **segmentation** of analysis worthy portions from the original stream. LVA can process from 0.4 seconds to 1,2 or 3 seconds of continues voice segments.

3. First **Time-Line** analysis to extract most of the minute emotional indictors.

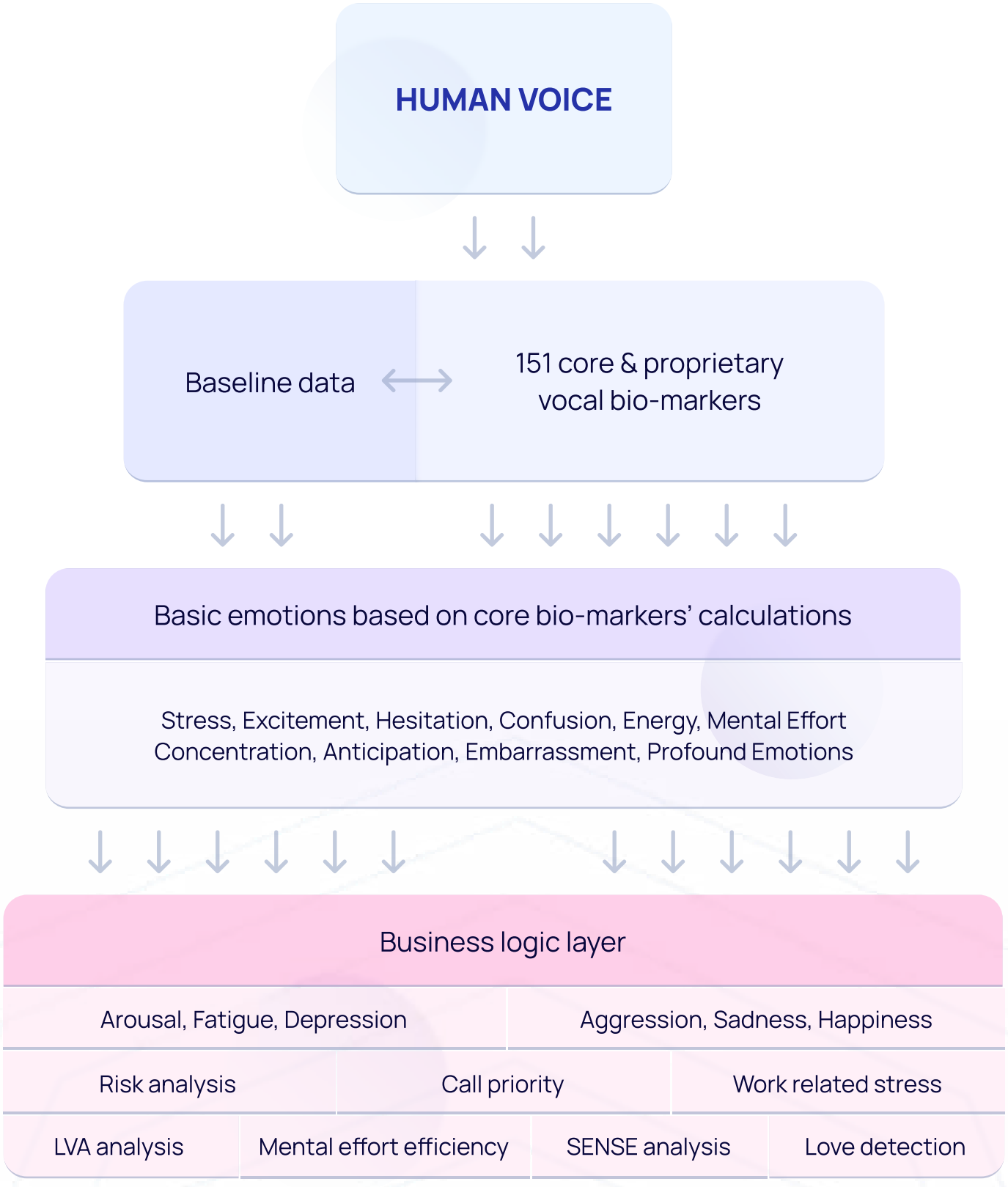
4. **Frequency** analysis to complete the sets of the more stable emotional states.

5. Second data optimization and Time-Line analysis to extract another order of parameters indicative of special type of stress we've learned to correlate with clinical conditions.

6. Once the entire set of 151 basic vocal indicators are captured, a set of 16 emotions is calculated in the total LVA process, these are:
   - Stress, Excitement, Uncertainty, Energy.
   - Mental Effort, Hesitation, CL stress (the clinical one).
   - Concentration, Anticipation, Embarrassment.
   - Sub-EMO, Sub-COG and arousal. (Sub-EMO is indicative of a generally emotional state, while Sub-COG indicates "heavy feeling", concern and deep logic).
   - Happy, Sad, Aggression.

7. These values are then used in the different business logics that are typically application dependent to drive an end result.

For LVA and risk assessment analysis, the system also computes a base-line set of values, so it can calculate the homostasis state of the speaker, and then identify significant changes in the emotional state.



4. THE EDP PLATFORM

Nemesysco's EDP (Emotion Detection & Personality) Platform uses the LVA basic parameters to compile additional types of emotions and outputs, and a set of parameters describing personality traits based on repeating emotional indications.

4.1 THE EMOTIONAL DIAMOND

To show the complexity of human emotional reactions in a simple and graphical way, we came up with the Emotional Diamond concept.

It presents LVA's 8 most natural reactions, and can show the way they change over time, as the evaluated person speaks. Notice the way it is built – Energy at the top, Stress at the bottom, Emotional to the right, Logic & Confidence to the left.

4.2 DEEPER "CLINICAL"- LIKE STRESS ANALYSIS

The EDP contains a sub-system for semi "clinical" stress detection that can be used for monitoring different deep stress levels and allows the operator to act upon it.

Stress levels are provided as a set of two values - high/low, and a final determination code. High and low values indicate the normally high and low stress levels of the tested party based on the averages of several consecutive segments. The low value is normally the more important variable, since it indicates how RELAXED the tested party can still potentially become, and if low enough, the tested party can still find ways to reduce his own stress.

Below are the Stress Report and Warning Level return value.
The return code is the warning level based on the stress levels, and is one of the following:

NMS_SD_NOSTRESS (0)	No clinical stress was detected. Note: you may find this indication in angry calls. This is not an analysis error; anger is a way the brain uses to dissolve stress.
NMS_SD_LOW (1)	Some low levels of stress were detected, but there is no need to be alerted.
NMS_SD_MID_TEMP_OK (2)	Although relatively high levels of stress were detected from time to time, there is still no reason to be alerted, as the tested party's clStressLow level is still considered low.
NMS_SD_HIGH_TEMP_OK (3)	Although relatively high levels of stress were detected often, there is still no reason to be alerted, as the tested party clStressLow level is still considered low.
NMS_SD_MID_WARN (4)	The system detected a relatively high level of stress from time to time, and the tested party does not seem to be able to relax properly. This is the time to take an affirmative action.
NMS_SD_HIGH_WARN (5)	The system detected a high ratio of highly stressful segments, and the tested party does not seem to be able to relax. This is a very high stress level and should be treated accordingly.
NMS_SD_DANGERLEVEL (6)	The system detected a dangerous level of stress that may soon begin to show symptoms if not already done so. This is the time to take action to relieve the stress or assist the tested party now.

PLEASE NOTE!

This function monitors ONLY the **Stress levels**, and not any other emotion. It is possible that the tested parties **will feel angry or extremely excited** (which may also be dangerous for their health), and yet the system will return with the NO STRESS indication. Stress is a very specific emotion, and in fact, anger is the opposite psychological reaction to stress.

5. TECHNICAL USE

5.1 AUDIO FORMATS

The LVA technology at the core is able to analyze recordings from a file or streaming voice directly from almost any source, as long as it is provided into the core in one of the following formats: 6/8/11 KHz sampling rates, in 8/16 bit depth, single channel (mono), non-compressed PCM format.

The technology generates best results when analyzing a stream/file of only one party in a conversation separated from other voices. Analysis of mixed voices is expected to reduce the detection accuracy drastically.

5.2 CALIBRATION TYPES

The calibration process is the initial phase performed by the LVA to determine and detect the acceptable ranges of the Basic Parameters in the specific session and working environment. LVA has two built-in types of Calibrations:

TYPE 1

The original calibration, which takes the first 5-10 segments for the calibration purpose, while producing partial results during the calibration phase.

TYPE 2

Shorter calibration process that uses only the first voice segment for this purpose.

For most systems, and in most instances, it is advised to use the Type 1 Calibration. Normally, you would want to define the Calibration type as a constant, and use the same type every time. It is advised not to change the Calibration type, even intermittently, as it will have an impact on the Emotional Signature creation and analysis.

5.3 SEGMENT LENGTH

LVA can be configured to segment the streaming voice data into Voice Segments of maximum length of 1 second, 2 seconds or 3 seconds. Note that the system may still produce shorter Voice Segments than the maximum according to its internal logic.

Shorter segments may produce more rapid data, however, with “sharper” changes, since the human voice is very sensitive to emotional brain activity, and that is a very fast, normally somewhat “spiky” process.

Longer segments will produce a more stable analysis, often eliminating the sharp changes and “generalizing” the emotions, however, depending on your needs, may prove to be too slow for your specific design, and when handling short calls, it may turn the analysis process completely unsuitable.

It is recommended to use the 2 second voice segments to benefit from both rapid and comprehensive results that are typically more “humanly understandable”. If you feel there is a room to consider other segment lengths, please feel free to consult with Emotion Logic at any rate.

5.4 DETERMINING THE BACKGROUND NOISE (BG) LEVEL

The default BG level is set to 1,000 in the demo codes, but there is no way to predict in advance the optimal BG level for each site without testing some of its recordings, as the BG level also relates to the working environment itself. Therefore, it is advised to obtain several voice sessions recorded in the destination environment, and by experimenting, determine the level that introduces a minimal number of noise segments, yet eliminating the minimal amount of real voice data.

NOTE!

Following this process, some sessions will surely contain a higher noise level. It should also be noted that a crying baby, a barking dog or a passing car could temporarily affect segment analysis results, as well as (sometimes) the emotional state of the speaker himself.

6. DESIGNING YOUR LVA BASED SYSTEM

The LVA can be used in many ways in your application. This section is designed to assist you with your new system design. Generally speaking, the LVA features can be used in 4 ways:

- Online/real-time analysis.
- Offline/post processing analysis.
- Emotional profiling – one time and over time.
- Report generation and KPIs

6.1 ONLINE / REAL-TIME IMPLEMENTATION

The core output readings are very extensive and change rapidly. In most real-time applications, the needs are far more limited. When designing your UI, you must consider the typical human operator capacity, additional duties and limited desktop or other interfaces' shared with various other indicators.

In addition, due to the nature of psychological reactions and the core's limitations, it is important never to look at the single voice segment as a determining factor, but to examine several sequential segments and **establish the emotional development trend.**

6.2 OFFLINE / POST PROCESSING ANALYSIS

Offline analysis of files provides the exact same data as the real-time analysis, but in this case, much more emotional data can be used and explored to provide better understanding about the users or subjects, their likes and dislikes. In addition to this “segment level data” analysis, several conversation summary reports are generated and can be used for different purposes.

When coupled with “word spotting” or “user identification” technologies, your system’s capabilities can be further enhanced by providing, for example, emotional analysis of specific key-phrases, such as different products, names, locations or features, and collect extended emotional profile of different subjects.

6.3 EMOTIONAL PROFILING

One’s emotional profile may be an important indication in any system design. Any decision making process assisted with this information may be able to produce better support approach, better system interface, or even better sales pitch more psychologically suited for this type of personality. The emotional profile is initially determined by the core after 5-6 voice segments and contains 8 emotional elements.

The emotional profile **should not** be considered as a constant value (per subject), and it is likely that in different interactions and different days the emotional profile will change to some degree, and will include different characteristics that may be more or less stable. As much as possible, it is actually recommended to monitor the changes in the emotional profile throughout the session and even over longer period of times to enable the detection of sharp changes that may be indicative of various significant events.

6.4 REPORT GENERATION

Based on the various emotions captured over time, your system can be programmed to generate various types of reports. For example, a specific performance over a period of time (anger, average stress levels, average energy levels in different hours of the day, etc.).

Averages of emotional values from different groups of users/topics over different periods of time, may reveal problems in different areas, for example, a sudden raise in the stress level of agents in a call center dealing with a certain product may indicate a mass detection of a failure in that product.

Tying geo-location to stress levels may improve navigation systems, and correlating aggression to specific phone numbers on a phone device may teach about the user's relationship with the speaker.

7. CALCULATED EMOTIONS - DEFINITIONS AND LIMITATIONS

The EDP technology produces a set of 12 normalized emotions and additional 5 indications of the tested party's emotional activity. These emotions are defined in the EmoVals structure:

Emotion	Emotion Type	Description	Ranges / Normal Level
Energy	Basic	Perhaps the most indicative parameter exposed. Conversation energy indicates if the speaker is sad or tired at low values (below 5), comfortable (5-9) or highly energetic (above 9). Values at the range of 0 to 1 may also indicate boredom.	Range is 0 to 50. Normally expected values **are between 3 to 9**
Content	Calculated	Indicates how pleased or happy the tested party is, but due to the psychological nature of different conversation modes, in times may appear in an argument as well.	0 to 30, normal value **is 0**
Energy	Calculated	Indicates how unpleased or sad the tested party is	0 to 30, normal value **is 0**
Angry	Calculated	Indicates how angry the tested party is. Please note that the system may accidently detect aggression in different conversation	0 to 30, normal value **is 0**
Stress	Basic	Indicates how nervous the tested party is.	0 to 30, normal value **is 0**

Emotion	Emotion Type	Description	Ranges / Normal Level
Embarrassment / Unease	Basic	Indicates how uncomfortable the tested party is.	0 to 30, normal value **is 0**
Intensive Thinking	Basic	Indicates the tested party is thinking intensively while speaking.	0 to 30, normal value **is below 3**
Imagination Activity	Basic	Indicates that the tested party is either recalling information from his memory or visualizing something.	0 to 30, normal value **is 0**
Hesitation	Basic	Indicates how comfortable the tested party was when making the statement. Below 14, the subject is more comfortable than normal; above 17, the subject is regretting what he is saying.	0 to 30, normal range **is 14-17**
Uncertainty	Basic	Indicates how certain or uncertain the tested party is about what was said. Below 15, the subject is more certain; above 15, the subject is more uncertain.	0 to 30, normal value **is 15**
Excitement	Basic	Indicates how positively or negatively excited the tested party is. Below 15, excitement is negative; above 15, indicates higher excitement or aggression.	0 to 30, normal value **is 15**
Concentration Level	Basic	Indicates how concentrated the tested party is.	0 to 30, normal value **is 0**

Emotion	Emotion Type	Description	Ranges / Normal Level
SAF/ Passion	Calculated	Arousal factor, indicating deep and profound interest in the conversation topic (positive or negative!).	0 to 30, normal value **is 0**
Extreme State	Basic	A value indicating how extreme the overall emotional activity is according to a unique logic pre-programmed in the EDP Core.	0 to 30, normal value **is 0**
Brain Power (OCA)	General	Overall summary of both emotional and logical processes in the brain. Used mainly for research purposes, but may also be useful assisting through research for your own needs and alert definitions.	0 – 6000 (both theoretical) Normal ranges **are between 700 and 1000**
EmoCog Ratio	General	Indicates rationality of the subject, i.e., to what extent the subject is talking based on emotions or logic. Above 100, the subject is more emotional; below 100, the subject is more logical.	1 to 5000 (both theoretical) Normal ranges **are between 50 to 150**

*** Happiness/Anger Conflict** – When people get angry and involved in an argument, or when "revenging", they may respond (in the segment level) with sudden unexplained "happiness", that may or may not appear together with the aggression indication. Although this phenomenon can be easily explained psychologically, sometimes it is not immediately clear when reviewing the results. Consider this fact when designing your own system.

APPENDIX 1 - LVA SHORT FACTS LIST

01 LVA technology was invented and has been continuously developed since 1997 in Israel, originally for homeland security purposes. Its development was initiated in response to a terror attack that took the lives of 3 young mothers in Israel

02 Emotion Logic is a daughter company of Nemesysco. Nemesysco was founded in April 2000 and develop LVA technology and solutions for a variety of fields, including security applications, financial fraud prevention, medical and psychological use and for personal safety

03 Emotion Logic systems are used in many countries around the world investigating crimes, fighting fraud, aiding psychologists in treatment and assisting customer service centers.

04 Emotion Logic invests constantly in academic research and typically at any given time more than few research projects are ongoing. A list of published research and results is available at Nemesysco.com

05 Many relates to LVA by mistake as a Lie -Detector. There is no such thing as a REAL LIE-DETECTOR, and LVA should not be considered as such too.

GET STARTED →