The Intelligence of the Heart

Antonella Vannini[1]

Abstract

In his "*Unitary Theory of the Physical and Biological World*" Fantappiè stated that anticipated waves do not obey classical causation; therefore they cannot be studied with experiments which obey the classical experimental method (Fantappiè, 1942). According to Wheeler's and Feynman's electrodynamics, emitters coincide with retarded fields, which propagate into the future, while absorbers coincide with advanced fields, which propagate backward-in-time. This time-symmetric model leads to predictions identical with those of conventional electrodynamics. For this reason it is impossible to distinguish between time-symmetric results and conventional results (Wheeler, 1949). In his transactional interpretations of quantum mechanics, Cramer states that "*Nature, in a very subtle way, may be engaging in backwards-in-time handshaking. But the use of this mechanism is not available to experimental investigators even at the microscopic level. The completed transaction erases all advanced effects, so that no advanced wave signaling is possible. The future can affect the past only very indirectly, by offering possibilities for transactions.*" (Cramer, 1986) Nevertheless, living systems constantly seem to be engaged in anticipation, and show behavior which cannot be explained by classical causation or studied in classical laboratory settings. When considering that according to Fantappiè living systems are a direct expression of retrocausality, it becomes plausible that retrocausality can be tested using living systems. For example, a general hypothesis is that "*if life is sustained by syntropy, the parameters of the autonomic nervous systems that support vital functions should react in advance to stimuli.*" And indeed an impressive number of studies have now shown that the autonomic nervous system (as measured by skin conductance and heart rate) can react *before* a stimulus is shown. In this paper I'm going to describe briefly the experiments I've conducted during my PhD and discuss the implications in the field of the intelligence of the heart.

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Introduction

Various experiments show the existence of anticipatory pre-stimuli reactions of skin conductance and heart rate, for example:

- One such experimental study, performed by Radin in 1997, monitored heart rate, skin conductance and fingertip blood volume in subjects who were shown a blank screen for five seconds and randomly selected a calm or emotional picture for the following three seconds. Radin found significant differences, in the autonomic parameters preceding the exposure to emotional versus calm pictures. In 2003 Spottiswoode and May replicated Radin's experiments, adding controls to exclude artifacts and alternative explanations (Spottiswoode, 2003). Results showed an increase in skin conductance 2-3 seconds before emotional stimuli are presented ($p=0.0005$). Similar results have been obtained by other authors, using various parameters of the autonomic nervous system, for example: McCraty, Atkinson and Bradley in 2004, Radin and Schlitz in 2005 and May, Paulinyi and Vassy in 2005.
- In the article "*Heart Rate Differences between Targets and Non-targets in Intuitive Tasks*", Tressoldi describes two experiments which show anticipatory heart rate reactions (Tressoldi, 2005). Trials were divided in 3 phases: in the *presentation phase* 4 pictures (landscapes, animals, monuments) were shown for about 10 seconds, and heart rate data was collected; in the *choice phase* pictures were presented simultaneously and the subject was asked to guess the picture which the computer would select; in the *target phase* the computer selected randomly one of the four pictures (target picture) and showed it on the monitor. In the first experiment a heart rate difference of 0.59 HR was measured in phase 1 during the presentation of target and non target pictures, ($t = 2.42$, $p=0.015$). In the second experiment the heart rate difference was 0.57 HR ($t = 3.4$, $p=0.001$).
- Studying neurological patients affected by decision making deficits, Antonio Damasio noted that specific lesions of the prefrontal cortex (PFC), especially in those sectors which integrate signals arriving from the body, lead to an absence or the imperfect perception of somatic feelings linked to emotions and to a behavior which can be described as "*shortsighted toward the future*". Damasio suggested a somatic markers (SM) hypothesis, according to which emotions constitute a part of the decision making process, instead of opposing it. Damasio describes SM in the following way (Damasio, 1994): "*When the negative outcome of a decision comes to our mind, a negative feeling is felt in the stomach. Because this feeling is relative to the body, I used the technical name somatic state; and because it marks an image, the word marker.*" SM can be measured as reactions of the autonomic nervous system using the parameters of skin conductance. Results of experiments show 3 types of autonomic nervous system responses in the form of skin conductance variations: two are observed after the gratification due to a gain and the punishment due to a loss, one is observed before the subject decides what to choose. Damasio interprets the anticipatory reaction of skin conductance as an effect of learning
- Daryl Bem, psychology professor at the Cornell University, studies retrocausality using well known experimental designs in a "time-reverse" pattern. In his 2011 article "*Feeling the Future:*

Experimental Evidence for Anomalous Retroactive Influence on Cognition and Affect", Bem describes 9 well-established psychological effects in which the usual sequence of events was reversed, so that the individual's responses were obtained before rather than after the stimulus events occurred. For example in a typical priming experiment the subject is asked to judge if the image is positive (pleasant) or negative (unpleasant), pressing a button as quickly as possible. The response time (RT) is registered. Just before the image a "positive" or "negative" word is briefly shown. This word is named "prime". Subjects tend to respond more quickly when the prime is congruent with the following image (either positive or negative), whereas the reaction times become longer when they are not congruent (one is positive and the other one is negative). In retro-priming experiments Bem used IAPS (International Affective Picture System) emotional pictures. Results show the classical priming effect with faster reaction times when the prime is congruent with the image. Considering all 9 experiments, conducted on a sample of more than 1,000 students, the retrocausal effect size is $p = 1.34 \times 10^{-11}$ (Bem, 2011).

Unpredictable random sequences and retrocausality

In order to test the existence of retrocausal effects, the fundamental condition is the availability of unpredictable sequences, that is to say pure random sequences. In a random sequence each term is totally independent from the previous and following terms; no rule links different parts of the sequence. This condition is known as unpredictability of random sequences and it is referred to as "lack of memory": the process of random selection does not recall any information about the values which were selected previously and cannot be used for the prediction of the values which will be selected in the future. The basic difference between *causal* and *random* can be traced back to the fact that *causal* events can be predicted, whereas *random* events cannot be predicted. As a consequence a *random* sequence can be defined as a sequence that no cognitive process will ever be able to predict. Random sequences imply the following qualities:

- *Unpredictability*. The knowledge of any portion of the random sequence does not provide useful information in order to predict the outcome of any other element of the sequence. In other words, the knowledge of the first k values does not provide any element in order to predict the value k+1: this property is called unpredictability.
- *Equiprobability*. A sequence is random if in each position each value has the same probability to be selected. In the case of a dice, each side has the same probability to be selected. Similarly, equal probability is expected when using a coin: during each tossing heads and tails have the same probabilities to show. Equiprobability implies independent sequences as it requires that the outcome of each selection is independent from any previous selection. A consequence of equiprobability is flat frequency distributions as each term, in time, will show a similar number of selections as the other terms.
- *Irregularity*. Unpredictability requires random sequences to be irregular and not repetitive.
- *Absence of order.* In random sequences no type of structure or order can be detected.

Computer languages usually use the word *random* to identify the instruction which starts the algorithm for random selection of numbers. In my experiments I used the Delphi-Pascal programming language which has a predefined random sequence (2^{32} numbers) which can be assessed through a pointer which can be defined by the user or by the value of the built-in clock. Utilizing the same pointer the selection of random numbers from the predefined random sequence will always be the same. The problem with random numbers produced by computer software arises when the pointer is recalled in a loop. As a consequence of the fact that each loop requires always the same processing time the new value read from the built-in clock will be determined by the previous one. In other words "random" numbers generated by the computer are all determined by the first pointer which was selected: the first pointer determines the second one, and so on, and the condition of independency between different terms is not met. Usually the fact that the sequences generated by computers are pseudorandom is considered of secondary importance. However, in experiments which want to test anticipatory effects, and which are based on the assumption of unpredictability, a pseudo-random sequence would inevitably be considered an artifact in the experimental design. The solution to this problem is incredibly simple. Since the problem arises from the fact that loops between pointers have the same interval, in order to overcome this problem, obtaining in this way pure random numbers, it is necessary to use loops which are based on unpredictable periods of time. This condition can be easily met when an external, unpredictable factor, is inserted in the loop and modifies its execution time. In the experiments conducted in this study, in which the subject was asked to press a button corresponding to the color that he/she thinks the computer will select, the reaction time of the subject is the unpredictable factor. In this way, the unpredictable reaction time of the subject makes the loop between pointers become unpredictable, and the value read from the built-in clock of the computer becomes independent from the other values previously read. In this way the independence among different selections is restored and the sequence becomes totally unpredictable: perfectly random. For this reason, in all the experiments which I have conducted studying the anticipatory effect, the subject was asked to operate a selection.

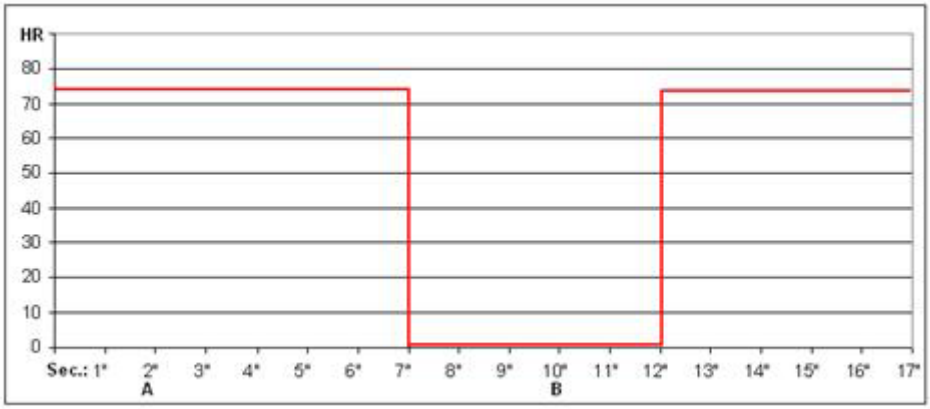
Measuring autonomic parameters

In late 2007 I started an assessment of the devices which could be used in order to measure the parameters of the autonomic nervous system. Researchers who had used skin conductance devices reported problems in the reliability of these measurements; I therefore focused on heart rate devices. My main requirement was to be able to synchronize heart rate measurements with the stimuli shown by the computer. I found that most devices used clocks different from that used by the computer during the execution of the experiment. I contacted several producers and distributors of laboratory devices, but they all had developed proprietary built-in software and did not agree to provide the software keys which would have allowed to development personalized software. In December 2007 the assessment was extended to devices used outside the labs field. After a long evaluation, the "*home training*" device produced by SUUNTO (www.suunto.com), was chosen. This system includes a thorax belt for measuring heart rate parameters and a USB interface (PC-POD) which receives measurements by radio, using digital coded signals (which eliminate any possibility of

interference) directly on the PC on which the experiment is carried out and using in this way the clock of the computer. The SUUNTO heart rate monitor provides a measurement of the heart rate frequency every second and saves this information in a file associated with the exact time (year, month, day, hour, minute and second). The measurement is saved compensating the delay due to the time required to perform the measurement and to process the information. The heart rate information is saved as an integer number, without any decimal values. The technical support unit of SUUNTO was contacted in Helsinki and gave full cooperation sending all the necessary documentation, software and .ddl libraries. SUUNTO underlined that synchronization and precision of measurements are diverging parameters. A precise synchronization diminishes the precision of the measurement. The SUUNTO "home training" device has been developed in order to monitor sport training activities and can be used in the most extreme conditions, for example underwater. It does not need the use of gel in order to conduct the signal and its use is extremely simple. Consequently it does not require the presence of an assistant in the same room in which the experiment is carried out.

Before starting the experiments the synchronization of the SUUNTO heart rate device with the clock of the PC was assessed. The heart rate information is shown in "real time" on the PC monitor and it is also saved in a file. In order to assess the synchronization a simple test was carried out moving the device away from the chest of the subject (point A in the following graphs) and moving the device back on the chest of the subject (point B).

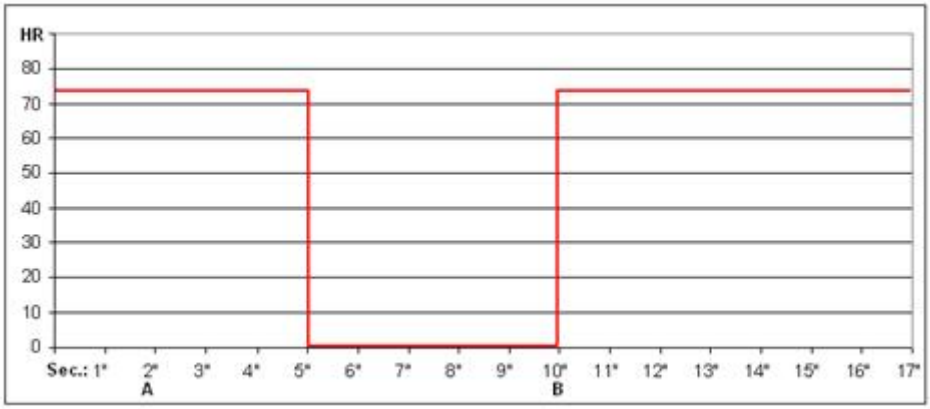
In real time on the PC monitor it was observed that when the signal is deactivated (moving the device away from the chest of the subject, point A) the measurement disappears after 5 seconds; when the signal is reactivated (moving the device back on the chest of the subject, point B) the measurement reappears after 2 seconds.



Behavior SUUNTO heart rate measurements on the PC monitor

In the data saved in the file it was observed that when the signal is deactivated (moving the device away from the chest of the subject, point A) the last measurement is kept for 3 seconds; when the signal is reactivated (moving the device back on the chest of the subject, point B) ***the measurement reappears immediately***.

This control shows that the delay in the measurements shown in "real time" on the PC monitor is approximately of 2 seconds, while in the data file the delay is compensated and the measurement is associated to the exact time.

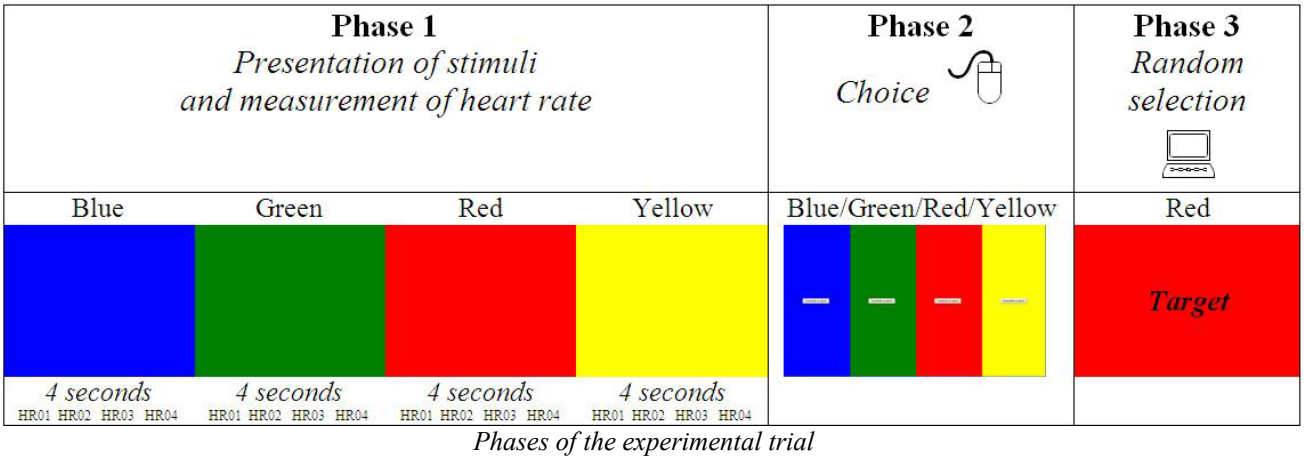


Behavior of SUUNTO heart rate measurements saved in the data file

Choice of stimuli

The first trials used stimuli made of black bars placed horizontally, vertically and diagonally on a white background. Data analysis did not show any significant anticipatory effect. The hypothesis was therefore analyzed in more depth and it was noticed that the "*syntropy effect*" should be mediated by emotions. Following this indication it was decided to use 4 elementary colors: blue, green, red and yellow. Using these colors, a strong anticipatory effect, in the form of difference in the heart frequencies, was immediately observed.

The first experiment was conducted using software developed in Visual Basic 2005 the last three experiments used software developed in Delphi Pascal which allows a better control of the computer hardware and a more precise synchronization of the presentation of the images. The experimental is divided into three phases.



Phases of the experimental trial

1. *Presentation phase* in which 4 colors were presented one after the other on the screen of the computer: blue, green, red and the yellow. Each color was shown for exactly 4 seconds. The subject was asked to look at the colors, and during the presentation the heart frequency was measured at fixed intervals of 1 second. For each color 4 measurements of the heart frequency were saved: one each second. The presentation of the color was perfectly synchronized with the heart rate measurement. When necessary the synchronization was re-established showing a white image before the presentation of the first color in phase 1.
2. *Choice phase,* at the end of the presentation of the 4 colors, an image with 4 color bars was shown (blue, green, red and yellow) in order to allow the subject to choose (using the mouse) the color which he/she thought the computer would select. In other words, the subject was asked to guess the choice performed by the computer.
3. *Target phase:* as soon as the subject chose a color the computer selected the target color, using a random process, and showed it full-screen on the computer.

Target is the color selected by the computer after the subject performs the guess.

Experiments

Four experiments were conducted using this experimental trial.

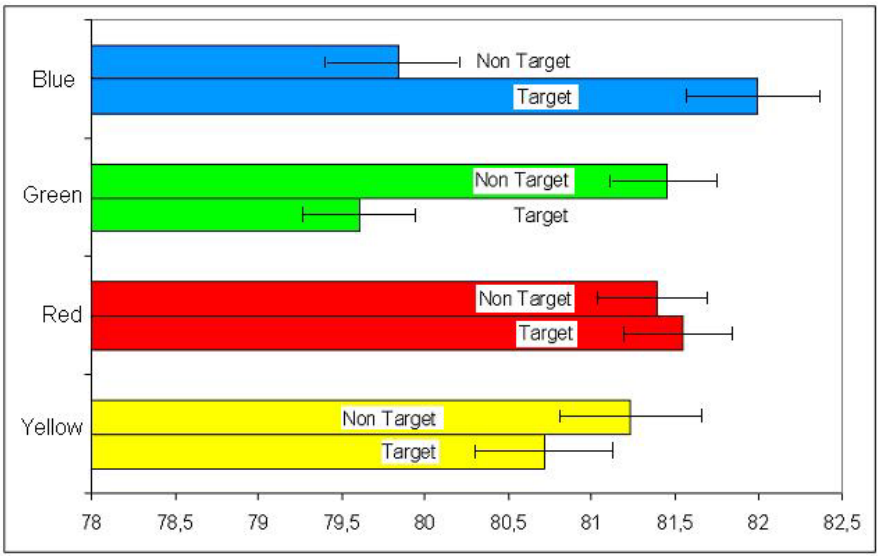
- Experiment n. 1

The hypothesis of the first experiment was: "*in presence of a retrocausal effect differences should be observed between heart rates measured in phase 1 during the presentation of target colors (colors which will be selected by the computer in phase 3 using an unpredictable random procedure) and non-target colors (colors which have not been selected by the computer in phase 3).*"

The experiment was conducted on a sample of 24 subjects, with ages ranging from 15 to 75 years. A total of 14 females and 10 males were present in this sample. Each subject performed the experiment 3 times, for a total time of slightly more than 20 minutes. Heart rate frequency was measured 960 times for each subject, producing a sample of heart rate frequencies which allows calculating statistical significances also within each subject.

Taking into account all the heart rate frequencies no significant difference were observed between target and non-target images; the target images obtained an average value of the heart rate frequency of 80.94 and the non-target images of 80.97. But, when the analysis was conducted within each color, strong differences of the heart rate were observed for the blue color when it was target (81.99 HR) and when it was non-target (79.84 HR) and the green color when it was target (79.60) and when it was non-target (81.45). These differences correspond to a t of Student value of 10.74 for the blue color, and 8.81 for the green color. A t Student value of 3.291 is statistically significant with $p<0.001$, meaning that there is less than 1 probability in 1,000 to be wrong when

stating that the difference is not a product of chance. A t of Student of 8.81 (obtained comparing the target and non-target images of the green color) tells that the probability of being wrong is practically equal to zero; it is therefore possible to state, with almost absolute certainty, that there is a difference between target and non-target images, which is not a consequence of chance.



Mean heart rate frequency divided by color and target

Even though a strong anticipated heart rate difference was observed, no ability of the subjects to guess the target was noticed. As a whole, 26.8% of the total guesses were correct, one out of 4, which is what we would expect by chance. In other words the rational conscious side seems unable to access the anticipatory information which is observed in heart frequencies.

Strong individual differences were observed. While most subjects showed a tendency towards higher heart rate frequencies when blue was target and lower heart rate frequencies when green was target, two subjects showed strong results in the opposite direction. Using t of Student and ANOVA statistical techniques, in which values are added, opposite significant effects are subtracted and result in a null effect. Therefore, when effects show in different directions among subjects, instead of adding they cancel each other, leading to a Type II error: affirming that the effect does not exist when it exists. For example, in the colors red and yellow statistically significant effects were observed within the subjects, but these effects were diverging; in the general analysis these effects disappear and result in a null effect.

- *Control of artifacts*

Artifacts are systematic errors which lead to observe effects which do not exist. Sometimes artifacts are used intentionally by the experimenter in order to reach the desired results; other times they consist in simple errors which produce accidental effects.

For example:

- Errors linked to the *experimental design* are often caused by intervening variables which have not been controlled. For instance, if in the experimental group the treatment is a substance, a drug in the form of a pill, while the control group does not receive any substance (no placebo pill), at the end of the experiment it will be impossible to say if the observed effect was caused by the substance in the pill or by the placebo effect of the pill.
- Errors can be caused by *non-homogeneous groups*. Experiments are usually based on the comparison of groups, for example those who have received a drug and those who have received a placebo. The attribution of subjects to groups is randomized in order to distribute equally all the characteristics of the population in the groups. However, in order to obtain homogeneous groups, randomization requires samples with a high number of subjects. Experiments are often conducted on small size samples, and characteristics such as instruction, income, health, are not equally distributed among groups. If in a group a higher proportion of highly educated subjects is present it might cause differences among groups. These differences can be erroneously attributed to the "experimental treatment", while instead they are a consequence of a different distribution of sample variables among groups.
- Errors linked with the *measuring device* happen when measurements are performed in systematically different ways among groups. When this happens differences observed can be the consequence of the ways measurements were performed.
- Errors linked to *statistical data analysis*. Statistical techniques can be affected by extreme values and the differences observed can be the consequence of these extreme values and not of the effect; furthermore, data might not comply with the requirements of the technique: this happens frequently when techniques which require the Gaussian distribution of data and additive effects are used.
- Errors can be linked to *intentional manipulation of data* by the experimenter in order to obtain the desired results.

In this work the control of these possible artifacts has been operated in the following ways:

- *Experimental design*. The experiment is designed in such a way that the only element which differs is the quality of the stimuli: target or non-target (selected or non-selected by the computer in phase 3). All the other conditions remain the same. It is therefore possible to state that the effect which is observed cannot be caused by any other variable, as no other variables exist which might be associated to the target or non-target condition of the stimulus during presentation.
- *Sampling*. Differently from other experiments in which the sample is divided in the experimental group and the control group, in this experiment the distinction between target and non-target stimuli is made within the same sample of subjects. This experimental design does not require, therefore, the randomization of the sample. Measurements cannot be affected by sample differences as the sample used is always the same.

- *Systematic measurement errors*. The measurement of heart rate frequencies is performed in the same identical way when target or non-target images are shown. No other variable associated with the measurement of heart rates frequencies during target and non-target images exists. Consequently no systematic error of measurement can be associated to target and non-target stimuli.
- *Statistical analysis of data*. Statistical analysis is always a very tricky field which hides problems of which the researcher might not be aware. In the last experiment described in this book statistical data analyses are performed using non parametric techniques, because the requirements for parametric techniques cannot be met. Statistical artifacts are quite frequent when using parametric techniques. These techniques can lead to Type I and II errors and these happen, for example, because of extreme values and because of non-directional effects, in other words effects which cannot be added. In this study these risks will be considered and non-parametric statistical techniques, based on the comparison of frequencies, will be used and described. Furthermore, in order to assess the validity of the results obtained, non-correlated targets (generated by the computer, but not shown to the subjects) were used. In the data analyses these targets did not produce any significant statistical difference. This control eliminated the doubt that statistical significances could be a product of chance.
- *Intentional manipulation of data and results by the experimenter*. Often, in order to participate in a congress, experimenters manipulate data sets in such a way that statistical significant results are obtained. The doubt of data manipulation remains as long as the same results are not replicated by other researchers. In the field of retrocausality similar results have been observed by researchers independently from the syntropy hypothesis.

The SUUNTO heart rate device used in these experiments has a range which goes from 30 heart rate beats per minute to 230 heart rate beats per minute, with a measuring error of ±0.5. One of the fundamental laws about measuring errors is that errors distribute according to a Gaussian curve, around the mean values. This law is known as the law of the sampling distribution of means and states that: "*the mean of the means of samples, coincides with the mean of the population from which the samples were taken.*" While the single measurement of the heart rate has an error of ±0.5 beats per minute, when mean values are used this error diminishes. Anyhow, the data analysis of the last experiment has been performed using non parametric techniques (Chi Square and Fisher's exact test) which do not require the comparison of mean values and do not require the precision of measurements which is required by parametric techniques. Generally speaking, the problem of the measuring device is assessed when no statistical differences are observed. In this study strong and statistically significant effects are observed and these effects are replicated each time.

- Experiment n. 2

The second experiment is intended to answer the following questions: Is the retrocausal effect observed only on blue and green colors? Is the retrocausal effect observed only using colors? Is the retrocausal effect observed only when the computer shows the target in phase 3?

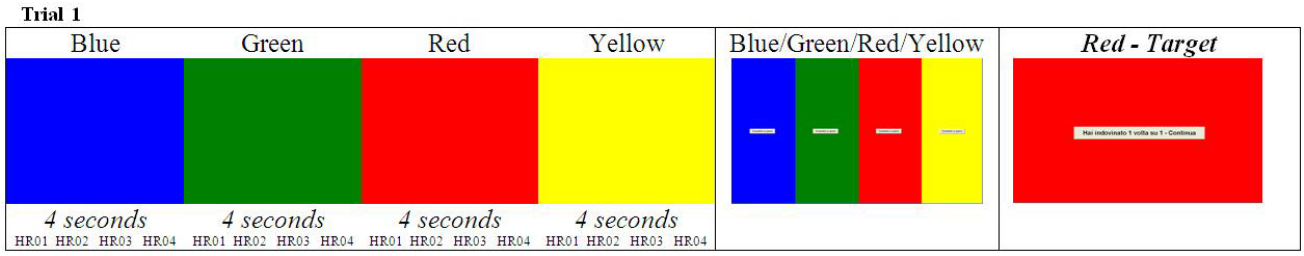
In order to answer these questions the experiment was organized in 5 different trials: in 3 trials the sequence of the colors was varied, in order to answer the first question; in one trial instead of colors numbers were used, in order to answer the second question; in one trial the target color was not shown, in order to answer the third question.

The effect was assessed in the form of differences between heart rates measured in phase 1 during the presentation of target colors (colors which will be selected by the computer in phase 3 using an unpredictable random procedure) and non-target colors (colors which have not been selected by the computer in phase 3).

The following hypotheses were formulated:

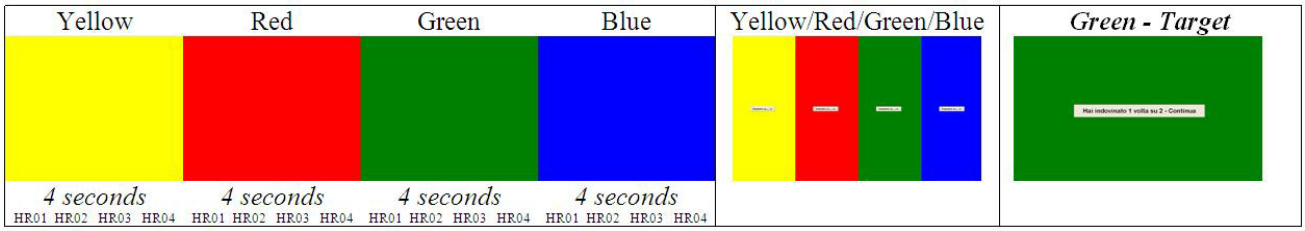
- The retrocausal effect is expected in all the trials in which the target is shown. The presentation of the target is considered to be the cause of the heart rate differences which are observed.
- The retrocausal effect is expected to show on all the colors. The hypothesis is that the retrocausal effect is transported by emotions and it is believed that all colors, and also stimuli different from colors, such as numbers, can have an emotional charge.

The experiment was based on 5 different trials, each one with a different sequence of colors and stimuli:



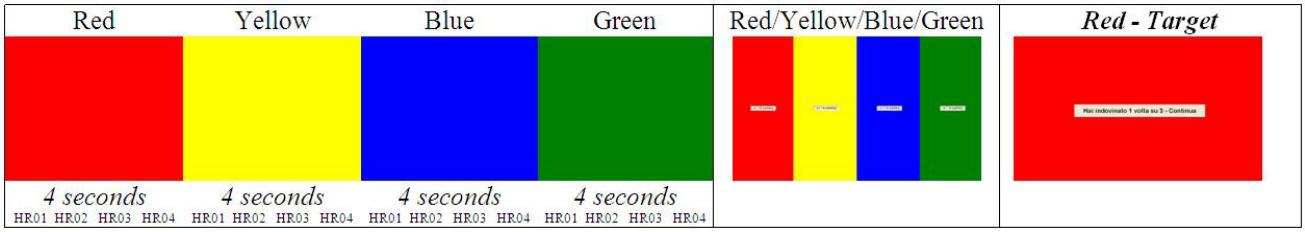
Trial n. 1: In phase 1 the sequence is blue, green, red and yellow and each color is presented for four seconds; in phase 2 the computer shows all the colors together and waits for the choice operated by the subject; in phase 3 the computer randomly selects the target color and shows it full screen for four seconds. A button is then shown with the percentage of times the subject has guessed correctly; the subject has to press the button in order to start a new trial.

Trial 2



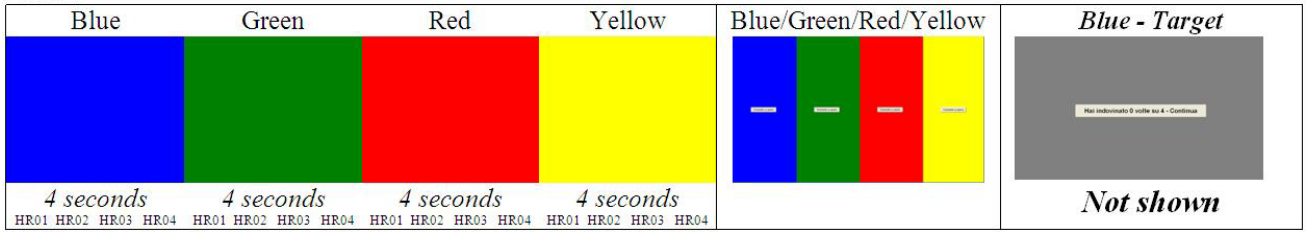
Trial n. 2: In phase 1 the sequence is yellow, red, green and blue and each color is presented for four seconds; in phase 2 the computer shows all the colors together and waits for the choice operated by the subject; in phase 3 the computer randomly selects the target color and shows it full screen for four seconds. A button is then shown with the percentage of times the subject has guessed correctly; the subject has to press the button in order to start a new trial.

Trial 3

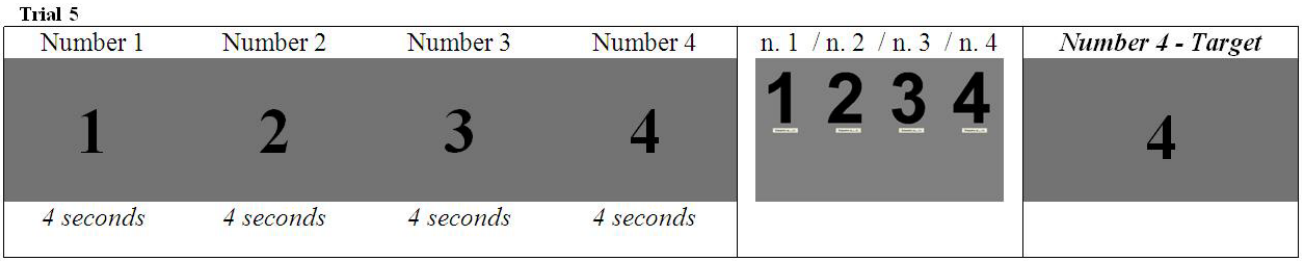


Trial n. 3: In phase 1 the sequence is green, blue, yellow and red and each color is presented for four seconds; in phase 2 the computer shows all the colors together and waits for the choice operated by the subject; in phase 3 the computer randomly selects the target color and shows it full screen for four seconds. A button is then shown with the percentage of times the subject has guessed correctly; the subject has to press the button in order to start a new trial.

Trial 4



Trial n. 4: In phase 1 the sequence is blue, green, red and yellow and each color is presented for four seconds; in phase 2 the computer shows all the colors together and waits for the choice operated by the subject; in phase 3 the computer randomly selects the target color but shows a grey screen for four seconds (**no presentation of the target**). A button is then shown with the percentage of times the subject has guessed correctly; the subject has to press the button in order to start a new trial.



Trial n. 5: In phase 1 the images are no. 1, no. 2, no. 3 and no. 4 and each number is presented for four seconds; in phase 2 the computer shows all the numbers together and waits for the choice operated by the subject; in phase 3 the computer randomly selects the target number and shows it full screen for four seconds. A button is then shown with the percentage of times the subject has guessed correctly; the subject has to press the button in order to start a new trial.

This sequence of 5 trials was repeated 20 times, reaching a total of 100 trials for each subject, for a total length of the experiment of slightly more than 45 minutes.

Heart rate was measured throughout all the experiments every second.

The sample was of 23 subjects, 14 females and 9 males, ranging from 16 to 61 years of age. The experiment consisted of 100 trials, 20 for each type, and required slightly more than 40 minutes. For each color in phase 1 only one measurement of the heart rate was used in the statistical data analysis. The number of heart rate measurements is therefore 400 (for each subject) x 23 (subjects) = 9,200 (Total).

The effect was studied using the *Student's t* test and was assessed as differences between heart rate measurements (taken in phase 1) of target and non-target stimuli (determined in phase 3).

Briefly, results show that: the effect is on all the colors and not only on the blue and green colors; the effect is present also when numbers are used instead of colors (in this experiment numbers from 1 to 4 were used); when the target is not shown the effect disappears. In the first 3 trials the computer shows the target, whereas in the fourth trial the target is not shown. Results confirm the fact that when the target is not shown (in phase 3) the effect (in phase 1) disappears. This result leads to the exclusion of causes which can precede the effect. The fifth trial shows a strong effect (t of Student -5.7) only on targets associated to the last position (number 4).

The first trial of this experiment is identical to the trial used in the first experiment, but statistically significant results are associated to the red and yellow colors and not to blue and green, as it was the case in the first experiment. In the first experiment it was noted that within subjects the effect was strong, but often with opposite directions among subjects. Therefore, when these effects are added together they tend to subtract and disappear and only the configuration which accidentally happens to be more represented in the sample remains statistically significant. This consideration shows how fallacious techniques like mean values, Student's t and ANOVA can be. In order to overcome this

limit in the last experiment the analysis is operated using statistical techniques which are based on the study of frequencies (Chi Square and exact test of Fisher).

In this second experiment non "correlated targets" (randomly produce by the computer in the data analysis phase) were added in order to assess if the values of statistical significance which were obtained could happen by chance. Data analysis showed that these uncorrelated targets were not associated with statistically significant differences in the heart rate frequencies measured in phase 1.

- Experiment n. 3

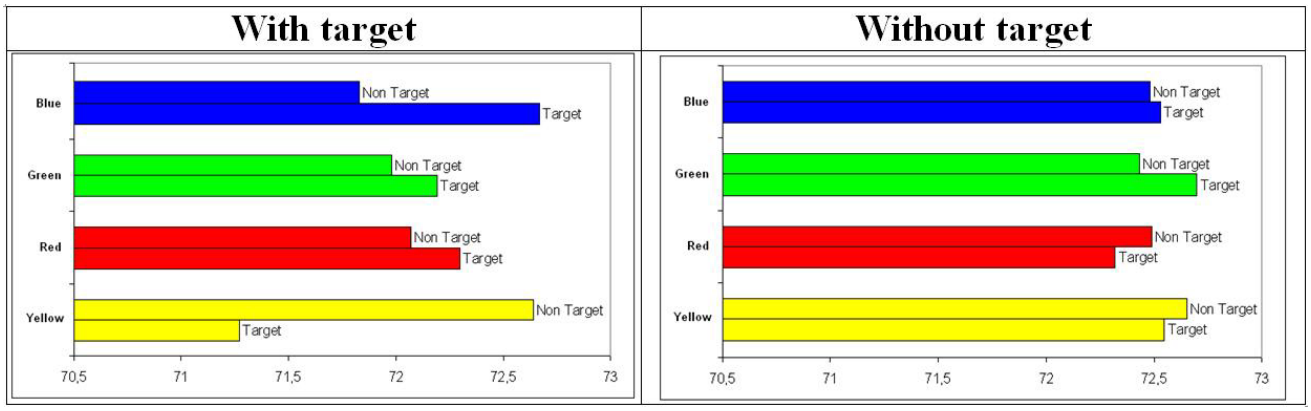
In the second experiment the control on the presentation of the target was performed showing a grey screen every 5 trials. This regularity could constitute an artifact. A third experiment was performed in which the grey screen was shown randomly instead of the target. Results show that when the target is shown strong differences are observed among target and non-target colors, whereas when the target is not shown these differences disappear. This control rules out the possibility that the difference between target and non-target colors can depend on causes which precede the selection operated by the computer (phase 3).

The experiment was intended to:

- Verify again the retrocausal effect in phase 1.
- Verify if the effect in phase 1 persists when the target is not shown. More precisely when the computer selects the target color (phase 3), but instead of showing it a grey full screen is shown.
- The hypothesis is that when the target is not shown the retrocausal effect should not show either.

The experiment consisted of 100 trials per subject, of which slightly less than 1 out of 5 were without target. The sample consisted of 8 subjects. Trials without target were chosen randomly by the computer. On a total of 800 trials 151 were without target presentation. On a total of 3,200 heart rate measurements (8 subjects x 100 trials x 4 stimuli) 604 were without target and 2,596 with target.

Results show that the retrocausal effect emerged with strong statistical differences within the blue and the yellow colors when the target was shown. On the other hand, the effect was totally absent when the computer, after performing the choice of the target color, did not show it on the monitor (trials without target).



Average heart rate values of the third experiment

In this experiment, as in the previous one, a slight tendency towards guessing correctly the outcome was noticed (26% compared to 25% which was expected). This difference is not statistically significant, but it is interesting to note that while in the first 50 trials 25.08% of the guesses were correct, in the last 50 trials this percentage increases to 26.95%. This increase suggests the existence of a learning process.

It is interesting to note that in the first experiment the effect was strong with the blue and green colors, while in this second experiment the effect on the green color was absent but was present on the yellow color. This modulation is a consequence of the fact that effects are not additive and when using mean values, *Student's t* or ANOVA subjects which show the effect, but in different directions, cancel each other.

- Experiment n. 4

The fourth experiment uses the same sequence of colors as the first experiment, but in the third phase (computer random choice) one color has a 35% chance of being selected by the computer (lucky color), one has a 15% chance (unlucky color) and the last two colors have a 25% chance (neutral colors). The task given to the subjects is to guess the highest number of colors selected by the computer (target). Subjects are not aware that colors have a different chance of being selected.

This design allows to distinguish Fantappiè's anticipatory effects due to retrocausality from Damasio's anticipatory effects due learning, since:

- Differences in heart rate frequencies observed in phase 1, in association with unpredictable random targets selected by the computer in phase 3 can be attributed only to a retrocausal effect, as a consequence of the fact that random selections are unpredictable (*retrocausal hypothesis*).
- Differences in heart rate frequencies observed in phase 1, in association with the choice operated by the subject in phase 2, can be interpreted as a learning effects (*learning hypothesis*).

- *Experimental hypotheses*

Hypotheses of this experiment are the following:

1. *Retrocausal hypothesis (reverse causality):* statistical significant differences in heart rate measured in phase 1 are expected in association with targets and non-targets.
2. *Learning hypothesis (causality):* according to the works of Damasio and Bechara (1994) a learning effect is expected in the form of heart rate differences measured in phase 1 in association with the choice (lucky and unlucky) operated by the subject in phase 2; these differences should increase during the conduct of the experiment.
3. *Interaction between retrocausal and learning effect (supercausality):* the retrocausal effect and the learning effect share similar somatic markers and are therefore both assessed through heart rates. The hypothesis is that at the beginning of the experiment only the retrocausal effect can be detected and then the learning effect starts disturbing the retrocausal effect which decreases; at the end the retrocausal and learning effect should separate and be independent. Clues about this hypothesis emerged during the development of the software. Subjects involved in the first 3 experiments reported a "butterfly" feeling in the stomach in association with the choice of target stimuli, whereas subjects involved in testing the design of this last experiment did not report the butterfly feeling and the retrocausal effect showed with less strength. These elements suggested that the learning effect could disturb the retrocausal effect.

- *Software*

From a software perspective the different probability for each target color was obtained selecting a number from 1 to 100. When the number was between 1 and 35 the lucky target color was selected, between 36 and 50 the unlucky target color was selected, between 51 and 75 the first neutral target color was selected and between 76 and 100 the last neutral target color was selected.

The same number could be selected again, making each number totally independent from the preceding one. This algorithm leads to the selection of lucky, unlucky and neutral colors in a proportion which does not coincide exactly with their probability. For example in the 3,000 trials of this experiment (30 subjects, 100 trials per subject) the lucky color was selected 36.15% times, the unlucky color 14.13% and the neutral colors 24.86%.

- *Feedback tables*

The experiment was conducted in the period March/April 2009, the following instructions were given to the experimenter: inform the subject about the total duration of the experiment (around 40 minutes); choose a quiet room, where the subject can be left alone for all the length of the experiment; start the recording of the heart rate frequency only after it has stabilized. Initially, heart rate frequency measurements are altered because of the movements that the subject undergoes in

order to apply the heart rate measuring device, generally speaking the stabilization of the heart rate measurements requires less than a minute from when the subject sits in front of the computer. Inform the subject about the task: try to guess the highest number of colors selected by the computer; begin the experiment only after starting the recording of the heart rate frequency; follow the subject for the first trial, in order to check that he/she has understood the task; leave the subject alone in the room where the experiment is carried out.

At the end of each experiment the following 2 files were merged: the *heart rate frequencies file* produced by the software Training Monitor 2.2.0 of SUUNTO. In this file heart rate measurements are associated with the time of the measurement. The *experiment data file*, developed in Delphi Pascal. This file contains the exact time of presentation of stimuli (in milliseconds), exactly synchronized with the beginning of the second, the choice operated by the subject and the selection operated by the computer, associated with the characteristics of the stimuli.

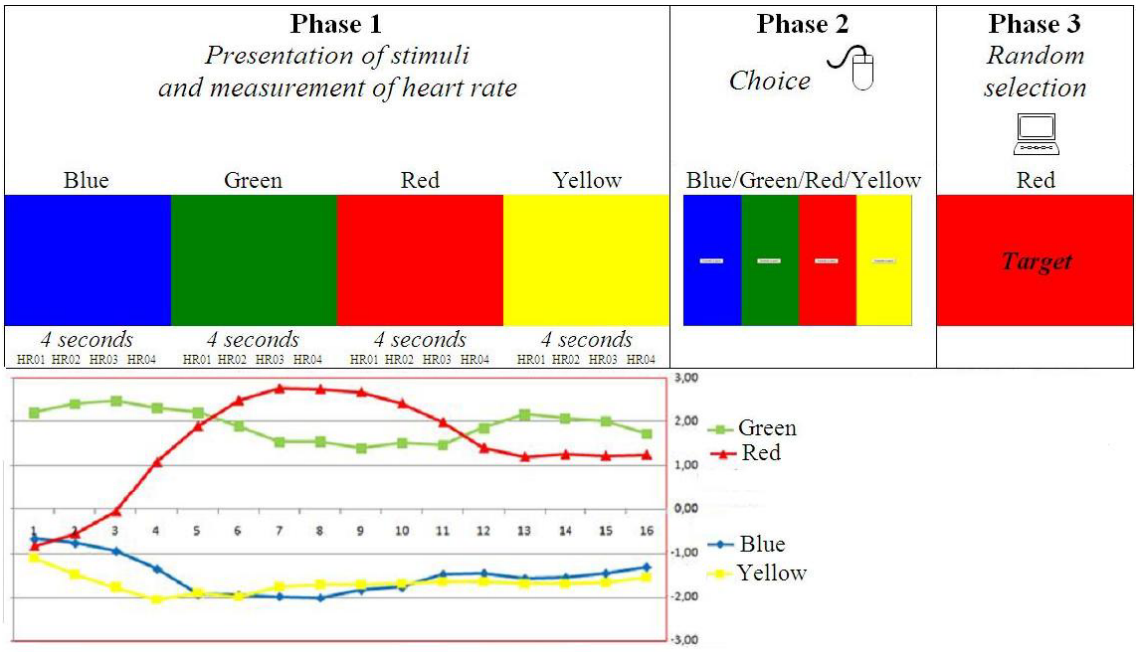
A data analysis was performed on this merged file in order to produce an immediate feedback table about the retrocausal effect for each subject. Feedback tables show if the effect is observed for each subject. An example is shown for subject n. 21 and subject n. 7. Feedback tables consist of 16 lines, one for each of the 16 heart rate frequencies measured in phase 1 of the experiment. Phase 1 is repeated 100 times. It is therefore possible to calculate 16 mean values for each color when it is target and for each color when it is not target. The differences of these mean values provide a feedback telling the strength of the retrocausal effect.

Example of feed-back table

Subject n. 21					Subject n. 7				
	Blue	Green	Red	Yellow		Blue	Green	Red	Yellow
HR 1:	-0.671	2.200	-0.840	-1.103	HR 1:	0.276	-0.775	0.040	0.378
HR 2:	-0.772	2.399	-0.556	-1.471	HR 2:	0.231	-0.750	0.133	0.298
HR 3:	-0.950	2.467	-0.056	-1.766	HR 3:	0.210	-0.862	0.173	0.414
HR 4:	-1.353	2.310	1.080	-2.054	HR 4:	0.150	-0.913	0.187	0.560
HR 5:	-1.928	2.204	1.894	-1.892	HR 5:	0.117	-0.850	0.187	0.545
HR 6:	-1.954	1.897	2.474	-1.993	HR 6:	0.048	-0.875	0.227	0.640
HR 7:	-1.982	1.535	2.752	-1.755	HR 7:	-0.067	-0.688	0.320	0.491
HR 8:	-2.015	1.543	2.733	-1.704	HR 8:	-0.077	-0.763	0.373	0.524
HR 9:	-1.831	1.397	2.665	-1.704	HR 9:	-0.129	-0.712	0.427	0.482
HR 10:	-1.770	1.508	2.407	-1.691	HR 10:	-0.109	-0.700	0.467	0.375
HR 11:	-1.482	1.468	1.981	-1.641	HR 11:	-0.174	-0.625	0.467	0.402
HR 12:	-1.458	1.853	1.404	-1.637	HR 12:	-0.249	-0.650	0.600	0.378
HR 13:	-1.572	2.154	1.199	-1.679	HR 13:	-0.259	-0.625	0.573	0.402
HR 14:	-1.544	2.079	1.260	-1.676	HR 14:	-0.296	-0.525	0.573	0.348
HR 15:	-1.452	1.994	1.226	-1.661	HR 15:	-0.283	-0.513	0.507	0.405
HR 16:	-1.311	1.727	1.255	-1.541	HR 16:	-0.220	-0.525	0.413	0.438
General total:	83.764				General total:	0.000			

Feedback table of the retrocausal effect

In the previous feedback table we see, for subject n. 21, that the heart rate frequencies in phase 1 when the target is blue compared to when the blue is not a target is lower by 0,671 heart beats. The second line is relative to the second heart rate frequency measured during phase 1 and its value for the blue color, when target, is -0,772 heart beats per minute. Feedback tables can be represented graphically in the following way:



Graphical representation of the feedback table for subject n. 21

This graphical representation shows that the effect spreads on all of phase 1, and it is not limited to heart rates measured in association with the presentation of the target color, as it was suggested by Tressoldi.

- *Effect: direction and sums*

In the first experiment it was observed that when the comparison between target and non-target is performed considering all the heart rate frequencies, no significant differences are observed, whereas when the comparison is performed within each color differences become strong and statistically significant. It was also noted, that subjects show strong and statistically significant effects, but in opposite directions. The fact that the direction of the effects can be in opposite directions and that when added together they produce a null effect, shows the inadequateness of technique such as *Student's t* and ANOVA. In neuropsychology and cognitive psychology effects are often non-additive, since they are not directional. In the experiments discussed in this work the direction of the effect depends on individual factors, since subjects react differently to colors according to the emotions which they associate to each color. Non directional effects cannot be added, and this hinders the use of parametric statistics which are based on adding and subtracting effects. In this case it becomes necessary to use statistical techniques which do not add or subtract

data and this led to choose techniques based on the analysis of frequency distributions. Data analysis was then carried out using non parametric statistical techniques such as Chi Square (χ^2) and the exact test of Fisher.

- *Data set*

The retrocausal effect is detected as differences between the mean values of heart rate frequencies measured in phase 1 in association with the target color selected by the computer in phase 3. It was decided to use a cut off value of 1.5, since this value is associated to a statistically significant effect ($p<0.01$) when considering one subject and 100 HR measurements. Global analyses were carried out considering this cut off value without negative or positive signs. Feedback tables were calculated for each subject. Trials were divided into 3 groups: the first 33 trials (starting from the second trial) the central 33 trials and the last 33 trials. The first trial was removed from data analyses because it was conducted with the presence of the experimenter. Consequently, data analyses have been conducted on the remaining 99 trials: from the 2nd to the 100th trial. Each value of a feedback table is associated with a color, a position of the HR in the trial, the number of the subject and the group of the trial.

In order to study the learning effect another set of feedback tables was used based on the mean values differences of the heart rate in association with the choice operated by the subject (in phase 2). It was decided to name these tables "*choice tables*". Choice tables were calculated for each subject, for each group of trial (first 33 trials, central 33 trials and last 33 trials) and are relative to each of the 16 HR measured in phase 1. The difference of the mean values of HR is calculated in association with the choice (lucky, unlucky and neutral) operated by the subject in phase 2.

The following example of a choice table shows how differences in the mean values of HR increase in the last 33 trials compared to the first 33 trials.

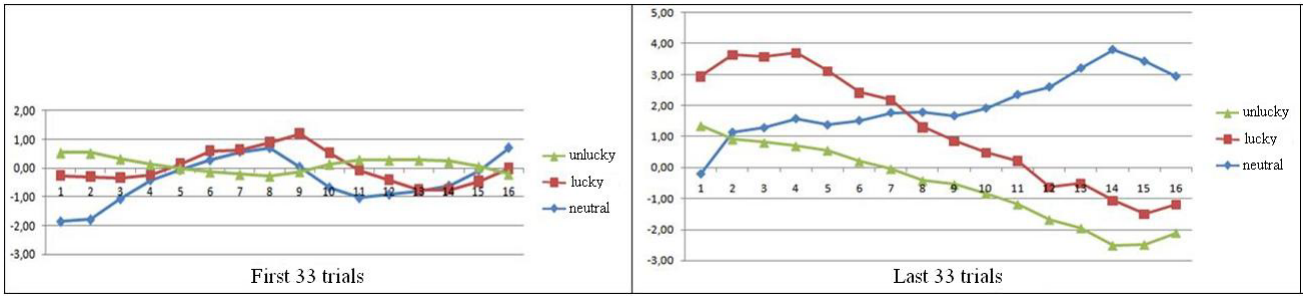
Differences in heart rate mean values measured in phase 1 in association with the choice operated by the subject in phase 2							
Subject 20 – first 33 trials				Subject 20 – last 33 trials			
Choice:	Neutral	Lucky	Unlucky	Choice:	Neutral	Lucky	Unlucky
HR 1:	-1.857	1.597	0.800	HR 1:	-0.202	3.143	-1.591
HR 2:	-1.790	1.472	0.845	HR 2:	1.136	2.507	-2.727
HR 3:	-1.070	0.722	0.675	HR 3:	1.283	2.300	-2.773
HR 4:	-0.412	0.167	0.380	HR 4:	1.577	2.121	-3.000
HR 5:	-0.055	0.181	-0.120	HR 5:	1.375	1.729	-2.545
HR 6:	0.283	0.306	-0.715	HR 6:	1.515	0.907	-2.227
HR 7:	0.577	0.056	-0.845	HR 7:	1.768	0.414	-2.227
HR 8:	0.706	0.194	-1.170	HR 8:	1.783	-0.479	-1.727
HR 9:	0.044	1.139	-1.290	HR 9:	1.669	-0.807	-1.409
HR 10:	-0.673	1.194	-0.375	HR 10:	1.915	-1.443	-1.318
HR 11:	-1.033	0.958	0.370	HR 11:	2.353	-2.136	-1.409
HR 12:	-0.912	0.500	0.700	HR 12:	2.599	-3.243	-1.045
HR 13:	-0.790	0.042	1.030	HR 13:	3.206	-3.714	-1.455
HR 14:	-0.614	-0.139	0.985	HR 14:	3.801	-4.871	-1.455
HR 15:	-0.070	-0.403	0.530	HR 15:	3.423	-4.921	-1.000
HR 16:	0.713	-0.736	-0.175	HR 16:	2.941	-4.143	-0.909
General total:	5.244			General total:	128.018		

Example of a "choice table"

Looking at choice tables of different subjects it is possible to note different configurations and it becomes clear again that statistical significance cannot be assessed using *Student's t*, ANOVA or any other parametric statistical technique.

The lines marked with HR (Heart Rate) indicate the 16 heart rates recorded in phase 1. Each experimental session included 100 trials; consequently there are 100 measurements for each experimental subject for HR 1, HR 2 … HR 16. It is therefore possible, for each HR, to calculate the difference of means associated to each choice the subject operates in phase 2: neutral, lucky and unlucky. Low values indicate no advance effect associated to the choice, whereas high values indicate an advanced effect. Figure 13 compares effects in the first 33 trials and last 33 trials of subject n. 20. This comparison shows a strong anticipated effect in the last trials, whereas no or very limited effect is observed in the first 33 trials.

The previous table can be translated into the following graphical representation:



Graphical representation of the learning effect for subject n. 20

This graphical representation shows a sharp increase in the learning effect from the first 33 trials to the last 33 trials.

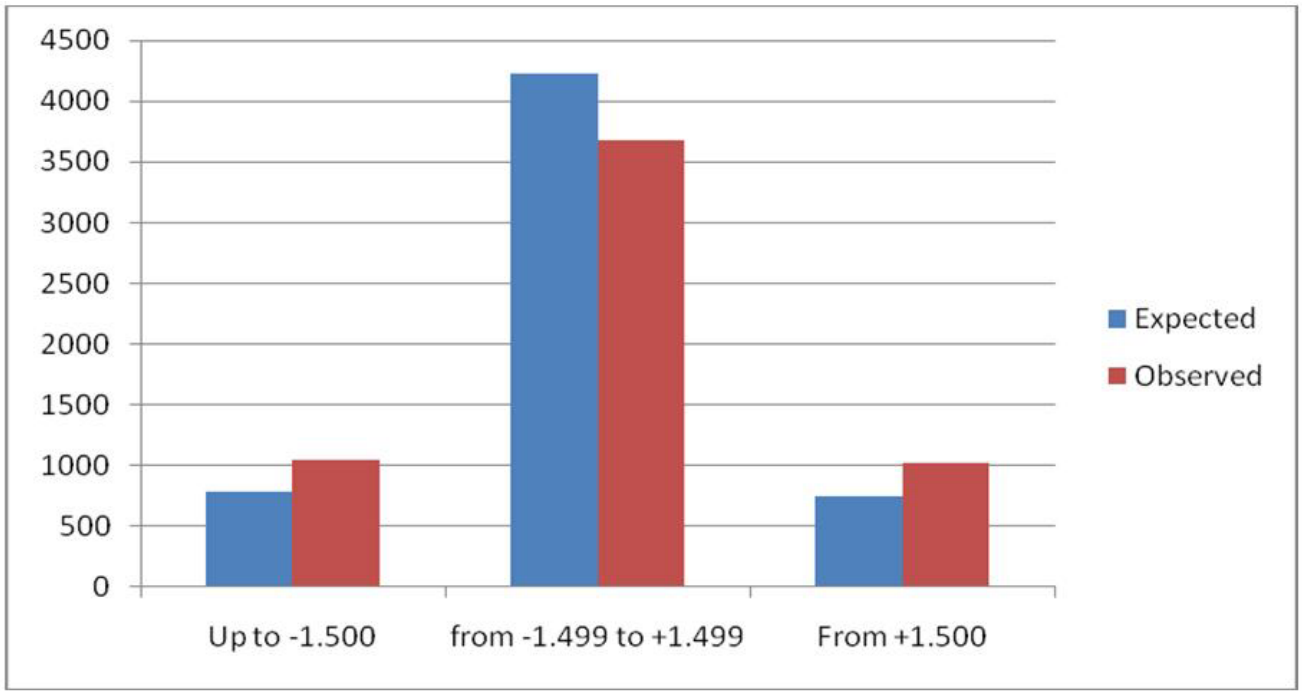
- *The retrocausal effect*

In order to have an "external criteria", statistical distributions that describe what happens when the effect is absent were calculated. These are named *Expected Frequencies*. This was done "empirically" using *non correlated targets* (NCT). NTC are targets generated by the computer during data analysis and which are not correlated with the targets selected in phase 3 by the computer during the experiment. NCT can be generated in many different ways, for example using loops, in which the first target is blue, the second green, the third red and the fourth yellow and repeating this sequence for all the 100 trials.

Using NCT for the calculation of expected frequencies and feedback tables for the calculation of observed frequencies, the following table was obtained.

Frequencies	*Differences of the mean values*			*Total*
	Up to -1.500	**-1.499 to +1.499**	**+1.500 and over**	
Observed	1053 (17.83%)	3680 (63.89%)	1027 (18.28%)	5760 (100%)
Expected	781 (13.56%)	4225 (73.35%)	754 (13.09%)	5760 (100%)

Observed and expected frequencies in the distribution of mean differences of HR, measured in phase 1 in association with the selection operated by the computer in phase 3.
Chi Square = 263.86. Values of Chi Square (df 2) are statistically significant (p<0.001) from 13.81



Observed and expected frequencies in the distribution of mean differences of HR measurements in phase 1 in association with the choice of the computer operated in phase 3 (see table 2).

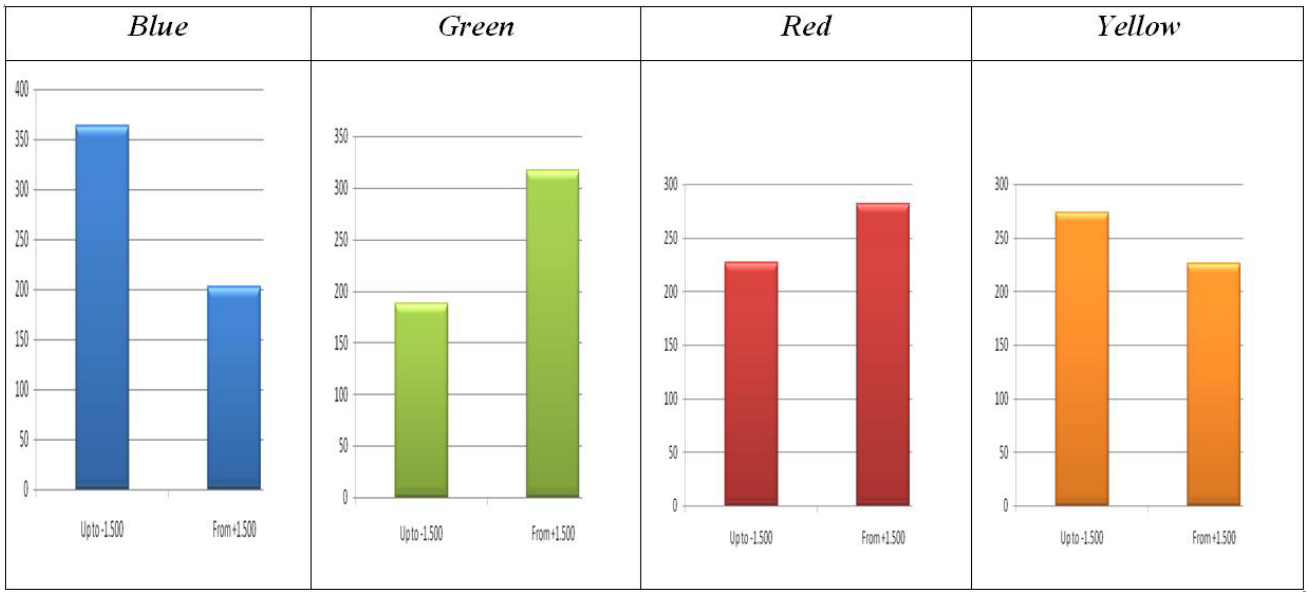
In the first group, on the left, differences up to -1.5 are associated with an observed frequency of 17.83% and an expected frequency of 13.56%; in the range from -1.499 to +1.499 the observed frequency is 63.89% compared to an expected frequency of 73.35%; on the right the observed frequency is 18.28%, the expected frequency is 13.09%. The difference between observed and expected frequencies is equal to a Chi Square value of 263.86 which, compared to 13.81 for a statistical significance of $p<0.001$, results to be extremely significant. It was not possible to use the exact test of Fisher as this test can be applied only on 2x2 tables. It is important to note that this data analysis based on frequency distributions is able to show a global effect that in the previous three experiments was impossible to observe since *Student's t* or ANOVA require additive data.

- How the retrocausal effect is distributed on colors

In previous experiments the retrocausal effect emerged on some colors and not on others and changed in a random way from one experiment to the other. This confusion was the result of the use of parametric statistics, which required additive effects whereas subjects were showing the effect in opposite directions. When the analysis is carried out using frequency tables the retrocausal effect is found on all the colors. For example (see next table) the blue color showed 14% of differences over +1.5 compared to 13.09% expected (NCT column) and 24.3% of differences under -1.5 compared to 13.56% expected. The Chi Square value of the effect on the blue color is 176.41 equivalent to $p<1/10^{27}$.

Differences	Colours				Total	N.C.T.
	Blue	Green	Red	Yellow		
From + 1.500	14.0%	22.0%	19.6%	15.7%	17.8%	13.09%
-1.499 to +1.499	60.7%	64.9%	64.6%	65.3%	63.9%	73.35%
Up to -1.500	25.3%	13.1%	15.8%	19.0%	18.3%	13.56%
	100% (n=1,440)	100% (n=1,440)	100% (n=1,440)	100% (n=1,440)	100% (n=5,760)	100.00%

Distribution of the differences of HR mean values (phase 1) associated with the selection operated by the computer (phase 3).



Whilst on the blue color the effect prevalently takes the form of a decrease in HR and on the green color it takes the form of an increase in the HR, for red and yellow the effect is distributed in a balanced way between subjects who show an increase in HR and subjects who show a decrease in HR, becoming therefore invisible to the Student's t and ANOVA analyses.

The previous graphical representation shows that for the blue and green colors the retrocausal effect is unbalanced. This unbalanced distribution of the positive and negative side of the effect permits to see the effect when using *Student's t* and ANOVA. In the case of the red and yellow colors, the negative side and positive side of the effect are balanced and become therefore invisible to *Student's t* and ANOVA as they cancel each other out. The prevalence of one side of the effect is totally accidental and this fact explains why the effect on colors showed in a random way in the first 3 experiments.

- Learning effect

Damasio's learning hypothesis states that the choice of the subject is preceded by the activation of neurophysiological parameters of the autonomic nervous system (Damasio, 1994) such as skin conductance and heart rate frequencies. It is therefore expected to see the activation of the heart rate

frequency in the last trials of the experiment, as a consequence of the fact that this is a learning effect.

Differences	Colour chosen by the subject			Total	N.C.T.
	Neutral	Lucky	Unlucky		
From + 1.500	14.0%	16.6%	17.2%	16.0%	13.1%
- 1,499 to +1,499	73.5%	66.0%	66.0%	68.5%	73.3%
Up to -1,500	12.5%	17.4%	16.8%	15.5%	13.6%
	100% (n=1,440)	100% (n=1,440)	100% (n=1,440)	100% (n=4,320)	100.0%

Global learning effect. Distribution of HR differences (phase 1) in association with the color chosen by the subject in phase 2. This table was calculated considering all the subjects and all the trials.

In this section data analysis is performed on *choice tables* which compare HR measured in phase 1 with the choice performed by the subject in phase 2. The global effect is divided into neutral, lucky and unlucky colors. The group "from +1.5" indicates increase of HR, whereas the group "up to -1.5" indicates decrease in HR, and the intermediate group indicates the absence of effect on HR. Data is expressed in the form of column percentages.

Observed and expected frequencies for neutral colors coincide, whereas for the lucky and unlucky colors they diverge with a Chi Square value of 39.15 ($p<1/10^9$) which shows the existence of a strong learning effect. The computer selects which are the lucky, unlucky and neutral colors at the beginning of the experiment, using a random procedure. No one during the execution of the experiment knows which are the lucky and unlucky colors. Only at the end of the experiment this information is saved in the data file and can be known. The hypothesis is that the learning effect should increase in time, while the experiment progresses and that it should be particularly strong in the last trials.

The next table shows the learning effect in the last 33 trials of the experiment. For example, in the case of lucky colors differences among mean HR values measured in phase 1 are greater than 1.5 19.2% of the times for lucky colors and 24% for unlucky colors compared to 13.1% which was expected.

Differences	Colour chosen by the subject			Total	N.C.T.
	Neutral	Lucky	Unlucky		
From + 1.500	15.8%	19.2%	24.0%	19.6%	13.1%
- 1.499 to +1.499	68.4%	57.7%	60.8%	62.3%	73.3%
Up to -1.500	15.8%	23.1%	15.2%	18.1%	13.6%
	100% (n=480)	100% (n=480)	100% (n=480)	100% (n=1.440)	100.0%

Distribution of the differences among mean HR values measured in phase 1 associated with the choice performed by the subject (phase 2). Table calculated on the last group of 33 trials, for all the subjects.

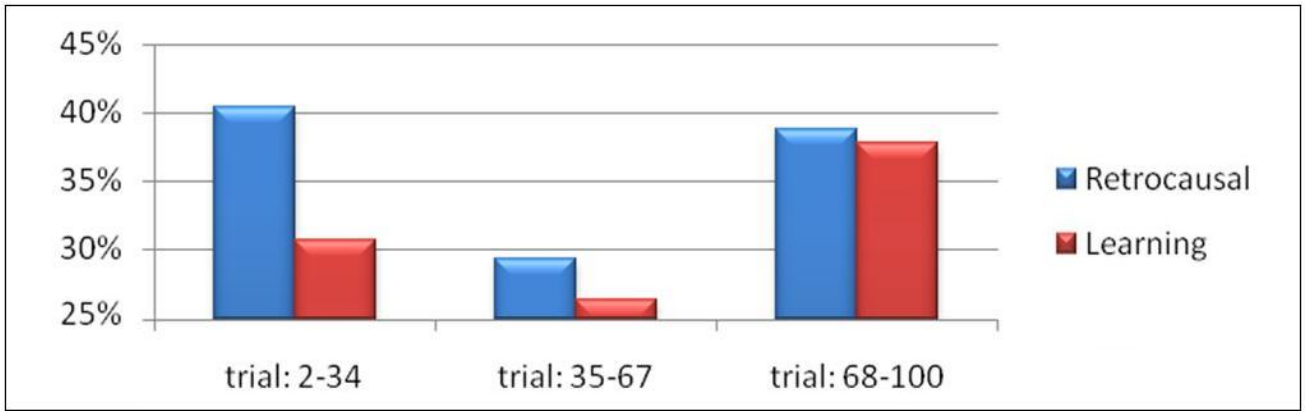
- Interaction between retrocausal and learning effects

The following table shows that in the first 33 trials 59.6% of the differences were below the 1.5 cut-off point, compared to 63.9% expected according to the total of the table and 73.3% according to the NCT criteria and 40.4% were above the 1.5 cut off point compared to 36.1% expected according to the totals of the table and 26.7% using the NCT criteria. In the intermediate 33 trials the observed effect is 29.2% compared to 26.7 expected by NCT. In the last 33 trials the effect is 38.8% compared to 26.7% expected according to NCT.

Differences (*absolute values*)	**Trial**			**Total**	**N.C.T.**
	2-34	**35-67**	**68-100**		
Up to 1.499	59.6%	70.8%	61.2%	63.9%	73,3%
From 1.500	40.4%	29.2%	38.8%	36.1%	26,7%
	100% (n=1,920)	100% (n=1,920)	100% (n=1,920)	100% (n=5,760)	100,0%

Distribution of mean HR differences in phase 1 associated with the target selected by the computer

The effect results to be strong and significant in the first 33 trials and in the last 33 trials. The effect can be assessed both with the NCT criteria and the totals of the tables. Using this last criteria, which results to be the most conservative one, in the first 33 trials the Chi Square value is 53.55 ($p<0.76/10^{13}$, 1 df, p=0.000000000000076). In the middle trials the retrocausal effect practically disappears, but in the last 33 trials it turns out again to be strongly significant with a Chi Square of a 39.31 ($p=0.95/10^{10}$, 1 df, p=0.000000000095).



Interaction between retrocausal and learning effect
Statistical significance of 1% starts at frequency values of 29%

It is possible to see a strong retrocausal effect in the first 33 trials and a limited learning effect. Then, in the middle trials both the learning and retrocausal effect disappear. At the end of the experiment, in the last 33 trials, both effects become strongly significant. The increase in the last 33 trials coincides with $p=0.95/10^{10}$ for the retrocausal effect and $p<1/10^{22}$ for the learning effect.

This trend suggests that in the first 33 trials the retrocausal effect is strong and the learning effect starts emerging, conflicting together both effects become incoherent and disappear in the middle 33

trials. The decrease of the retrocausal effect in the central part of the experiment had not been observed in previous experiments and can be attributed only to the interaction with the learning effect. In the last 33 trials a strong rise in both the effects is observed. This trend suggests an interaction between the learning and retrocausal effect which is probably the cause of the loss of the effect in the central part of the experiment.

The following table is relative to the effects shown by the subject with the highest values of general difference in feedback tables. In this example the retrocausal effect is extremely strong from the beginning of the experiment (73% compared to 26% expected), but it drastically drops down in the central part of the experiment and then climbs back up again.

Differences (*absolute values*)	**Trial**			**Total**	**N.C.T.**
	2-34	**35-67**	**68-100**		
Up to 1.499	26.6%	67.2%	29.7%	44.0%	73.3%
From 1.500	73.4%	32.8%	70.3%	56.0%	26.7%
	100% (n=64)	100% (n=64)	100% (n=64)	100% (n=192)	100.0%

Distribution of mean differences of HR measured in phase 1 in association with the target selected by the computer in phase 3. This table considers only the data of the subject with the highest retrocausal effect.

The learning effect which is observed in the form of HR differences is not translated into an improvement in the guesses of the subject. When the subject discovers the existence of a lucky color he/she could start choosing always this color, increasing in this way the guesses from 25% (random) to 35% of the lucky color. This increase was not observed, on the contrary in the first 33 trial the target was guessed correctly 24.75% times, in the middle trials 24.65% and in the last trials 25.47%. This slight increase is not statistically significant. It is therefore possible to state that in all the trials subjects guessed randomly even though the learning effect is clearly and strongly seen in HR differences.

- *Summary of the results*

Results shows:

- A strong retrocausal effect on the blue color $p<1/10^{27}$, green color $p<1/10^{12}$, red color $p<1/10^{13}$ and yellow color $p<1/10^{11}$.
- The retrocausal effect is observed starting from the first 33 trials, as expected by the hypothesis.
- A learning ($p=0.00000000023$) effect was observed before the choice of a lucky and an unlucky color (choice operated by the subject in phase 2). It is important to note that this effect emerges with strength in the last block of trials of the experiment, as was expected by the hypothesis, according to which a learning effect requires time to show.
- An interaction between the two effects is observed in the central part of the experiment in which the learning effect inhibits the retrocausal effect ($p=0.000000000000076$).

– Whilst a strong learning effect is observed in association with heart rate frequencies, this effect is not translated into more advantageous guesses. In all the blocks, subjects guess 25% as expected by the random distribution. Therefore the strong learning effect which is observed with heart rate frequencies is not translated into a cognitive learning.

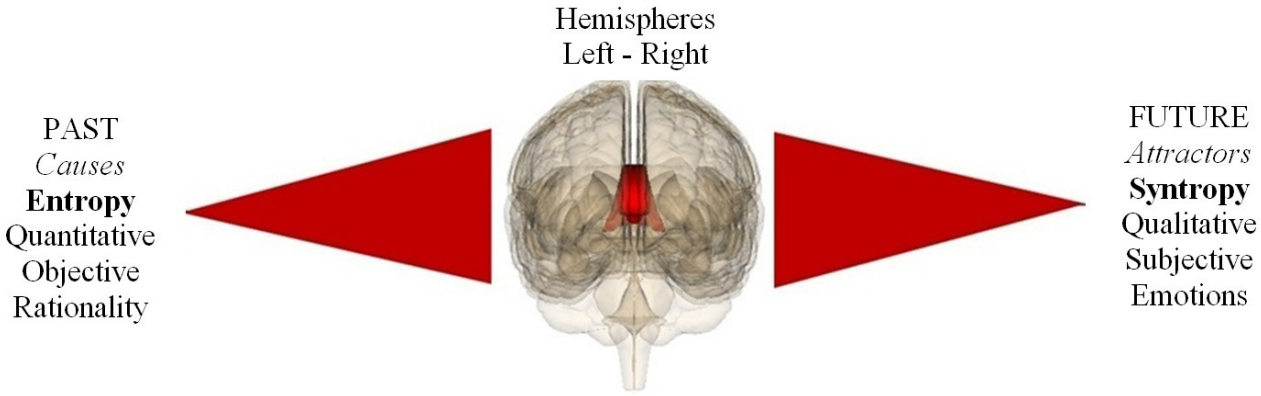
Considerations

According to the retrocausal hypothesis we participate to two different levels of time: sequential time, the level of our rational life in which time flows from the past to the future in a succession of absolute moments, and unitary time, the level of intuitions, of the heart, in which there is coexistence of past, present and future. The mathematician Chris King suggested that free will arises from the constant interaction between these two levels of time. This interaction requires that living systems make choices and free will would result from this constant process of choice. The present moment, according to this hypothesis, would be the meeting point of information arriving from the past and in-formation arriving from the future in the form of intuitions and heart feelings.

Interaction past/future and free will

We constantly choose between logical-rational thinking (forward in time solution of the fundamental equations) and emotional-intuitive thinking (backward in time solution). Since the positive and the negative solutions are perfectly balanced, a similar amount of information is received from the past and from the future. This would be the reason of the perfect division of the brain into two hemispheres.

The previous figure can, therefore, be represented replacing the human figure with the figure of the two cerebral hemispheres, where the left hemisphere is the seat of logical reasoning, rationality and language, and the right hemisphere processes intuitions and heart feelings.



Lateralization of brain functions

The forward-in-time solution takes the form of experience, learning and beliefs, whereas the backward-in-time solution takes the form of heart feelings, intuitions and presentiments. Since rational-logical thinking is characterized by objective and quantitative information which is perceived as "certain", whereas intuitive and heart thinking is characterized by subjective and qualitative experiences which are perceived as "uncertain", the tendency is to choose according to the logical-rational thinking penalizing intuitions that are closely related to syntropy.

The left hemisphere deals with the external and material world, characterized by objective information and analytical rational thinking, whereas the right hemisphere deals with our inner world, characterized by feelings, intuitive processes, symbols and images. Western culture has increasingly focused on rationality, diagrams, demonstrations of the real world, and considers writing and technical data the inner essence of things. We can describe an object in its characteristics, we can use standardized symbols to represent them, we can attempt to reconstruct retrospectively the parts of a whole by the analytical process of rationality, however we are not able to look at objects and ourselves from the inside and reach the essence of reality.

Generally speaking we tend to overlook intuitions, since it is widely believed that life must be based only on facts, models and information which derive from the past. This attitude has gradually led to abandon insights, inspirations and dreams, with the result that choices are now made taking into account only push factors, governed by the law of entropy, and not the pull factors governed by the law of syntropy.

The theory of syntropy introduces the autonomic nervous system in this design and, more specifically, the solar plexus. According to this theory the solar plexus would connect us with the source of Life Energy, and is therefore the seat of the "*feeling of existence*", the "*feeling of life*" and intelligence. The theory of syntropy leads to the belief that the inner reality of consciousness is a manifestation of Life Energy. Consciousness manifests itself through the solar plexus and, more generally, the autonomic nervous system. Today, on the contrary, consciousness is searched in the brain and brain processes. The role of the solar plexus and the autonomic nervous system is, for the most part, ignored.

References

Aharonov Y (2005), *Quantum Paradoxes*, Whiley-VCH, Berlin, 2005.

American Institute of Physics (2006), *Frontiers of Time. Retrocausation – Experimental and Theory*, AIP Conference Proceedings, San Diego California, 20-22- June 2006.

Bechara A (1997), Damasio H, Tranel D and Damasio AR, *Deciding Advantageously before Knowing the Advantageous Strategy*, Science, 1997, 275: 1293.

Bechara A (2005), Damasio H, Tranel D and Damasio AR, *The Iowa Gambling Task and the somatic marker hypothesis: some questions and answers*, Trends in Cognitive Sciences, 9: 4, April 2005.

Bem D (2011), *Feeling the future: Experimental evidence for anomalous retroactive influences on cognition and affect*, Journal of Personality and Social Psychology, Jan 31, 2011.

Bierman DJ (1998) and Radin DI, *Conscious and anomalous non-conscious emotional processes: A reversal of the arrow time? Toward a Science of Consciousness*, Tucson III. MIT Press 1998, 367-386.

Damasio AR (1994), *Descarte's Error. Emotion, Reason, and the Human Brain,* Putnam Publishing, 1994.

Damasio AR (1999), *The feeling of What Happens. Body and Emotions in the Making of Consciousness*, Harvest Book Harcourt, New York 1999.

Di Corpo U (2011a) and Vannini A, *Supercausality and complexity. Changing the rules in the study of causality*, Kindle Editions, ASIN: B005N5KLCE.

Dummett M (1954), *Can an Effect Precede its Cause*, Proceedings of the Aristotelian Society (Supp. 28).

Eccles JC (1989), *Evolution of the brain*, Routledge, Oxford 1989.

Eddignton A (1927), *The Nature of the Physical world*, Ann Arbor Paperbacks, University of Michigan Press, Ann Arbor 1958.

Einstein A (1916), *Relatività, esposizione divulgativa,* Universale Bollati Boringhieri, Torino 1967.

Fantappiè L (1942), *Sull'interpretazione dei potenziali anticipati della meccanica ondulatoria e su un principio di finalità che ne discende*. Rend. Acc. D'Italia, 7(4).

Fantappiè L (1944), *Principi di una teoria unitaria del mondo fisico e biologico.* Humanitas Nova, Roma 1944.

Fantappiè L (1993), *Conferenze scelte,* Di Renzo, Roma, 1993.

Feynman R (1949), *The Theory of Positrons*, Physical Review 76: 749.

Feynman R (1965), *Meccanica Quantistica,* in *La fisica di Feynman,* Vol.III, Zanichelli, Bologna 2001.

Frautschi S (1982), *Entropy in an expanding universe*, Science, vol. 217, Aug. 13, 1982, 593-599.

May EC (2005), Paulinyi T and Vassy Z, *Anomalous Anticipatory Skin Conductance Response to Acoustic Stimuli: Experimental Results and Speculation about a Mechanism*, The Journal of Alternative and Complementary Medicine. August 2005, 11(4): 695-702.

McCratly R (2004), Atkinson M and Bradely RT, *Electrophysiological Evidence of Intuition: Part 1*, Journal of Alternative and Complementary Medicine; 2004, 10(1): 133-143.

Poincaré H (1908), *Le raisonnement mathématique,* in *Science et méthode,* Flammarion, Paris.

Radin DI (1997), *Unconscious perception of future emotions: An experiment in presentiment*, Journal of Scientific Exploration, 1997, 11 (2): 163-180.

Radin DI (2005) and Schlitz MJ, *Gut feelings, intuition, and emotions: An exploratory study*, Journal of Alternative and Complementary Medicine, 2005, 11(4): 85-91.

Rosen R (1985), *Anticipatory Systems*, Pergamon Press, USA 1985.

Spottiswoode P (2003) and May E, *Skin Conductance Prestimulus Response: Analyses, Artifacts and a Pilot Study*, Journal of Scientific Exploration, 2003, 17(4): 617-641.

Szent-Gyorgyi A (1977), *Drive in Living Matter to Perfect Itself*, Synthesis 1, 1(1): 14-26.

Tressoldi PE (2005), Martinelli M, Massaccesi S and Sartori L, *Heart Rate Differences between Targets and Nontargets in Intuitive Tasks*, Human Physiology, 2005, 31(6): 646–650.

Vannini A (2010) and Di Corpo U, *Collapse of the wave function? Pre-stimuli heart rate reactions*, NeuroQuantology, 2010, 8(4): 550-563.

Wharton KB (2009), *A novel interpretation of the Klein-Gordon equation*, Foundation of Physics, 2009, 40(3): 313-332.

Wheeler J (1945) and Feynman R, *Interaction with the Absorber as the Mechanism of Radiation*, Review of Modern Physics (17).

Wheeler JA (1949) and Feynman RP, *Classical Electrodynamics in Terms of Direct Interparticle Action.* Reviews of Modern Physics 21 (July): 425-433.