# Advanced waves and pre-stimuli heart rate differences

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***Abstract***

Heart rate and skin conductance responses have been found to be present before stimuli were applied. In this paper the results of four different experiments on heart rate pre-stimuli reactions are presented. Results show that even though subjects guess randomly, a strong pre-stimuli difference in the heart rate is observed during the presentation of the color stimuli, later selected and shown by the computer. All four experiments have confirmed pre-stimuli reaction of heart rate, and have shown new characteristics of the effect. The first experiment shows strong differences in HR measured in phase 1 for the blue and the green colors when selected by the computer in phase 3. The second experiment shows strong differences for all the colors and also when numbers are used. The third experiment shows the absence of the effect when the feedback, the selection operated by the computer, is not shown. The fourth experiment shows the retrocausal effect on all colors, the learning effect described by Damasio and an interaction between these two effects.

## *Introduction*

The solutions of Klein-Gorodon's equation (quantum mechanics relativistic wave equation), which can be considered the fundamental equation of the universe, depends on a square root:

$$E\psi = \sqrt{p^2 + m^2}\psi$$

*Klein-Gordon's equation relates energy (E), momentum (p), m (mass) and Schrödinger's wave equation (ψ)*

Square roots always yields two solutions, one positive and one negative:

1. the positive solution describes waves and causes which propagate from the past to the future;
2. the negative solution describes waves and causes which propagate backwards from the future to the past.

In the 1930s the negative solution was rejected as it was considered incompatible with our experience of time which moves from the past to the future. However, as the mathematician Roger Penrose points out in his book "The Road to Reality" (Penrose, 2005) "*Usually physicists tend to reject as unphysical*

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*any solution which contradicts classical causality, according to which causes always precede effects. Any solution which makes it possible to send a signal backwards in time is usually rejected... but this refusal is a consequence of a subjective choice, towards which other physicists have different opinions.*" Penrose adds that the relativistically invariant version of Schrödinger's wave equation does not offer a procedure in order to exclude the negative solution and this creates a conflict with the law of classical causation.

In 1941 the mathematician Luigi Fantappiè, while studying the mathematical properties of the positive and negatives solution of Klein-Gordon's equation, found that:

1. The positive solution, which describes waves which diverge from the past to the future, is governed by the law of entropy which leads the system towards the dissipation of energy, the increase of homogeneity, disorder and heat death.
2. The negative solution, which describes waves which diverge from the future to the past and which correspond for us, to converging waves, are governed by a law symmetric to entropy which Fantappiè named Syntropy, which is characterized by concentration of energy, differentiation, order and growth of structures.

Fantappiè noted that the properties of the law of Syntropy coincide with the properties of living systems, arriving in this way to his "*Unitary theory of the physical and biological worlds*" (Fantappiè, 1944).

### *Hypothesis: autonomic nervous system and pre-stimuli reactions*

Fantappiè suggested that vital processes would feed on Syntropy, and consequently, in 1981 Ulisse Di Corpo suggested that the parameters of the autonomic nervous system, which supports vital functions, should react in advance to stimuli (Di Corpo 1981, 2007).

In the last decade a growing number of studies have shown the existence of pre-stimuli reactions in the parameters of skin conductance and heart rate. Anticipatory pre-stimuli reactions are neurophysiologic responses activated before the stimulus takes place. These anticipatory reactions are activated before the subject can receive indications or cues about the stimulus. In scientific literature, various experiments show the existence of anticipatory effects, for example:

- *Anticipatory reaction of skin conductance.* In 2003 Spottiswoode and May of the Cognitive Science Laboratory replicated Bierman and Radin (1997) experiments which show an increase in skin conductance 2-3 seconds before emotional stimuli are presented. Spottiswoode and May replicated these results obtaining a statistical significance of p=0.0005, and performed controls in order to exclude all possible artifacts and alternative explanations. These results support the hypothesis that the autonomic nervous system reacts in advance of stimuli (Spottiswoode and May, 2003).

- *Electrophysiological responses.* McCarty, Atkinson and Bradely in *"Electrophysiological Evidence of Intuition"* (2004) show the existence of strong anticipatory reactions of the electrophysiological parameters of the heart.

- *Pre-stimuli heart rate differences.* In his article "*Heart Rate Differences between Targets and Non Targets in Intuitive Tasks*", Tressoldi and coll. report results of two experiments aimed at investigating pre-stimuli heart rate changes. Results support the hypothesis that heart rate changes before stimuli are applied (Tressoldi 2005).

## *Experiments*

In this paper the results of four different experiments on heart rate pre-stimuli reactions are presented. A detailed description of these experiments was presented by Antonella Vannini in her PhD thesis (Vannini, 2010).

### *Procedure*

The four experiments are based on the experimental design devised by Tressoldi, but instead of complex images simple colors and numbers are used.

| **Phase 1** *Presentation of colors and measurement of heart rate* | | | | **Phase 2** *Choice* | **Phase 3** *Random selection* |
|---|---|---|---|---|---|
| Blue | Green | Red | Yellow | Blue/Green/Red/Yellow | Red |
| | | | | | ***Target*** |
| *4 seconds* | *4 seconds* | *4 seconds* | *4 seconds* | | ***Feedback*** |

*Table 2 – Phases of an experimental trial*

Each trial is divided into 3 phases (see table 2):

1) colors are presented on full screen for exactly 4 seconds and the heart rate is measured each second;
2) the experimental subject chooses one of the colors trying to guess the color which will be chosen by the computer;
3) the computer selects, using a random algorithm, one of the 4 colors (target) and shows it in full screen (feedback).

The hypothesis is that in the presence of advanced waves, a retrocausal effect, an anticipatory response in the form of statistically different heart rate values measured in phase 1, should be observed in concomitance to target and non target stimuli.

The "home training" heart rate belt produced by SUUNTO (www.suunto.com) was chosen as the measurement device. This device 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 same clock of the experiment.

Special attention was given to the random selection of stimuli in phase 3. Random extractions generated by computers are generally pseudorandom, as they are based on cycles which have the same interval, and which makes each extraction dependent on the previous one. When the time interval between extractions is unpredictable a pure random extraction takes place.

Phase 2 of the experimental trial had the following functions:

1. to make the time interval between extractions unpredictable, as it is based on the reaction time of the experimental subject;
2. to focalize the attention of the subject on the outcome, on the feedback selected by the computer.

*Experiment number 1*

Even though four heart rates were measured for each stimulus, only one HR per stimuli was included in the data analysis, in order to avoid any effect due to autocorrelation. Stimuli were 4 for each trial, and trials were 60 for each subject, therefore a total of 240 HR were available for each subject, 24 subjects participated in the experiment ant the total HR sample was therefore of 5,760 measurements.

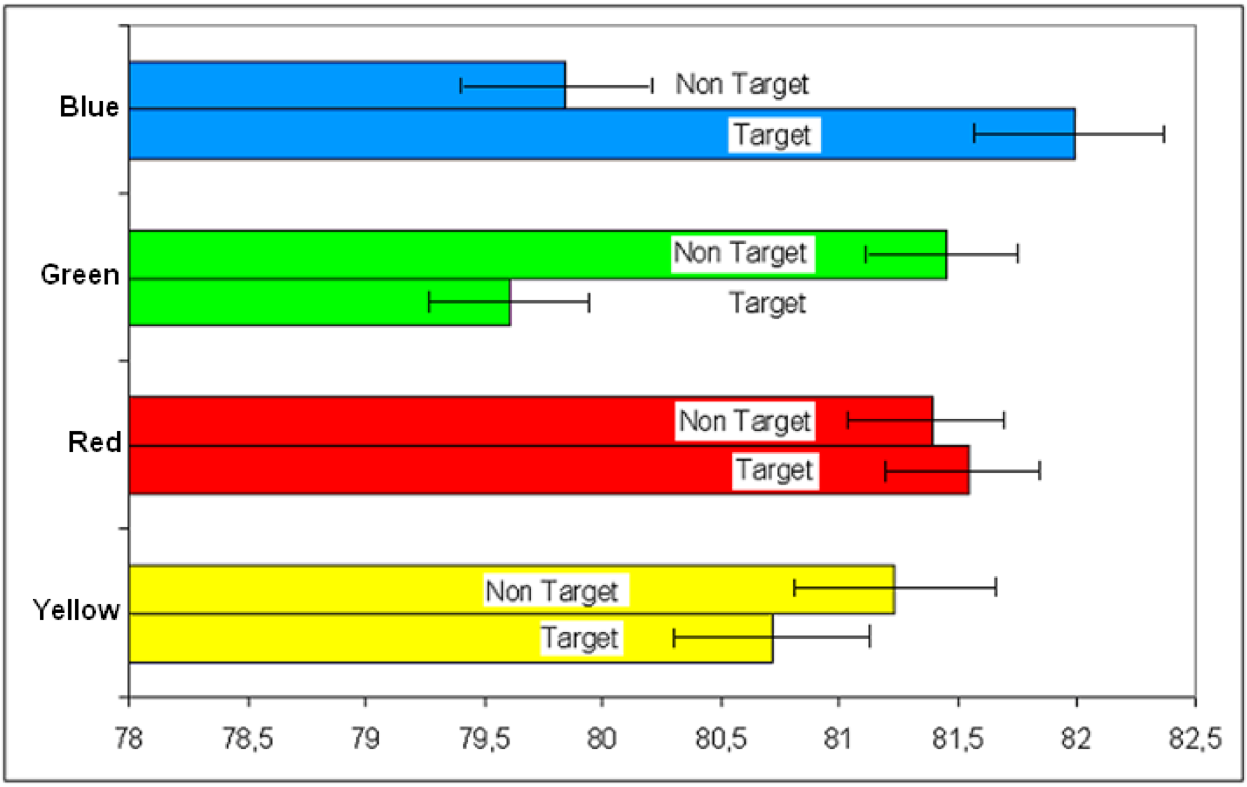



*Table 3 – Average HR for color when target and non target*

Data analysis was carried out comparing heart rate frequencies (HR) measured in phase 1. These HR were divided according to the selection of the target operated by the computer in phase 3. Comparisons were carried out between:

- Average HR values when blue is target and when the other colors are target.
- Average HR values when green is target and when the other colors are target.
- Average HR values when red is target and when the other colors are target.
- Average HR values when yellow is target and when the other colors are target.

It is important to note that the choice operated by the subject in phase 2 was not included in the data analysis.

Results show that globally there is no difference between HR associated to targets (80.94) and to non targets (80.97). However when data analysis is carried out within colors strong differences are observed for the blue color (Student t=10.74***) and green (Student t=8.81***), as it is shown in table 3.

*Experiment number 2*

The first experiment raised some questions:

1. Does the retrocausal effect show only with the blue and green color?
2. Does the retrocausal effect show only with colors?
3. Does the retrocausal effect show only when the computer shows the feedback?

In order to answer these questions the second experiment was devised in 5 blocks of trials:

1. In the first 3 trials the sequence of presentation of colors was changed in phase 1, in order to answer question number 1.
2. In the last trial numbers were used instead of colors in order to answer question number 2.
3. In the fourth trial the feedback was not shown in order to answer question number 3.

The data sample was of one HR per stimulus, stimuli were 4 for each trial, trials were repeated 100 times per subject and subjects were 23, reaching a HR sample of 9,200HR.

Results show that:

- the effect does show on all colors, and not only with the blue and green colors;
- the effect shows also when numbers are used, it is therefore not necessarily associated with colors;
- the effect is absent when the computer does not show the feedback.

In order to study possible statistical artifacts, fake targets which were not shown to the subjects were inserted in the data analysis. These fake targets did not show any statistically significant result.

| Phase 1<br>*Presentation of colors and measurement of heart rate* | | | | Phase 2<br>*Choice* | Phase 3<br>*Random Selection* |
|---|---|---|---|---|---|
| **Trial 1** | | | | | |
| Blue | Green | Red | Yellow | Blue/Green/Red/Yellow | ***Feedback*** |
| **Trial 2** | | | | | |
| Yellow | Red | Green | Blue | Yellow/Red/Green/Blue | ***Feedback*** |
| **Trial 3** | | | | | |
| Red | Yellow | Blue | Green | Red/Yellow/Blue/Green | ***Feedback*** |
| **Trial 4** | | | | | |
| Blue | Green | Red | Yellow | Blue/Green/Red/Yellow | ***No Feedback*** |
| **Trial 5** | | | | | |
| Number 1 | Number 2 | Number 3 | Number 4 | n. 1 / n. 2 / n. 3 / n. 4 | ***Feedback*** |
| **1** | **2** | **3** | **4** | 1 2 3 4 | **4** |

*Table 4 – Experiment n. 2 was divided in 5 trials which were repeated 20 times for each subject.*

*Experiment number 3*

In the second experiment, the absence of the feedback happened always in the fourth trial, and this could constitute an artifact. In the third experiment the sequence of colors in phase 1 was always the same, but the feedback was hidden at random, in an unpredictable way. Results show that the retrocausal effect of the heart rate appears only when the computer shows the feedback. The feedback of the computer, in phase 3, can therefore be considered the cause of the retrocausal effect which is measured in phase 1.

The data sample was made of 3,200HR: one HR per stimulus, 4 stimuli per trial, 100 trials per subject, for a total of 8 subjects. Among these 3,200HR, 2,596 were associated to feedbacks while 604 were not associated to feedbacks.

*How can these results be interpreted?*

Experimental designs based on sequences which are perfectly random and unpredictable, such as those used in the experiments which have just been described, avoid that the effect which has been observed can be the consequence of:

1. Implicit rules: no rule or cue can exist in a random sequence.
2. Expectation: an increase of HR due to expectation would spread equally on targets and non targets, while results show a strong correlation in HR variations with targets and non targets.
3. Causes which precede the effect. The absence of the effect in the condition “without feedback” clearly shows that the effect cannot be explained by causes preceding the effect.

*Considerations concerning the data analysis*

Often the retrocausal effect shows as an increase in HR when, for example, the target is blue; however in some subjects the same target produces an opposite effect decreasing HR.

When opposite effects are added the result is a null effect.

For this reason Student t and ANOVA, which require effects to be additive, are not suitable for the data analysis of these experiments. In order to avoid a type II error, in the last experiment data analysis will be carried out using Chi Square and Fisher F statistical tests.

*Retrocausality versus learning*

Studying neurological patients affected by decision making deficits, Damasio (1994) noted that specific lesions of the prefrontal cortex (PFC), especially in those sectors which integrate signals arriving from the body and which generate maps, lead to the absence or the imperfect perception of somatic feelings linked to emotions. Damasio says that these subjects are characterized by knowing but not by feeling. After prefrontal cortex impairments, emotions and feelings are compromised and patients lose the ability to choose the most advantageous direction, even if mental abilities are intact. These subjects show a behavior which can be described as "*short sighted toward the future*".

Damasio suggested the hypothesis, known as the hypothesis of the somatic markers (SM), that emotions are part of the network of reasoning and constitute a part of the decision making process, instead of opposing it. According to Damasio, emotions allow to operate advantageous choices, without having to produce advantageous assessments.

Damasio describes somatic markers in the following way: "*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.*"

Somatic markers can be measured as reactions of the autonomic nervous system (ANS) using the parameters of skin conductance, heart rates and body temperature.

Clinical and experimental evidence support the hypothesis of the somatic markers. The Iowa Gambling Task (IGT), which was devised by Bechara (Bechara, 1994) had the purpose to simulate real decision making processes, similar to those faced during everyday life (uncertainty, gains and losses). The results of these experiments show 3 types of autonomic nervous systems responses in the form of skin conductance variations:

Two are observed after:

1. the gratification due to a gain;
2. the punishment due to a loss.

One is observed before:

3. The subject decides the deck (lucky or unlucky) from which to extract the card.

Damasio interprets the anticipatory reaction of skin conductance as an effect of learning, whereas Tressoldi and Bierman suggest that this third anticipatory response can depend on retrocausality, extending in this way Damasio and Bechara's model.

*Procedure and data analysis*

A fourth experiment was carried out with the purpose of dissociating the retrocausal and learning effect. The experimental trial differs from the previous experiments in phase 3, where the computer extracts a random number from 1 to 100. When the number falls between:

- 1 and 35 the lucky color is extracted (35% chance);
- 36 and 50 the unlucky color is extracted (15% chance);
- 51 and 75 the first neutral color is selected (25% chance);
- 76 and 100 the second neutral color is selected (25% chance).

The same number can be extracted again, making in this way each extraction totally independent from the previous ones.

The retrocausal effect is assessed comparing the average values of HR measured in phase 1 according to the selection operated by the computer in phase 3. Comparisons are carried out between:

- Average HR values when blue is target and when other colors are target.
- Average HR values when green is target and when other colors are target.
- Average HR values when red is target and when other colors are target.
- Average HR values when yellow is target and when other colors are target.

Trials are repeated 100 times for each subject, it is therefore possible to produce these comparisons for each HR measured in phase 1 and for each subject. The learning effect is instead assessed comparing HR measured in phase 1 with the choice operated by the subject in phase 2. Comparisons are carried out between:

- Average HR values when subjects choose a lucky color and when other colors are chosen.
- Average HR values when subjects choose an unlucky color and when other colors are chosen.
- Average HR values when subjects chooses neutral colors and when other colors are chosen.

In this experiment data analysis differs from previous experiments as the average difference values of HR are calculated only within each subject.

| | | **Phase 3** | | | |
|---|---|---|---|---|---|
| | | Blue | Green | Red | Yellow |
| **Phase 1** | HR 1: | -0.671 | 2.200 | -0.840 | -1.103 |
| | HR 2: | -0.772 | 2.399 | -0.556 | -1.471 |
| | HR 3: | -0.950 | 2.467 | -0.056 | -1.766 |
| | HR 4: | -1.353 | 2.310 | 1.080 | -2.054 |
| | HR 5: | -1.928 | 2.204 | 1.894 | -1.892 |
| | HR 6: | -1.954 | 1.897 | 2.474 | -1.993 |
| | HR 7: | -1.982 | 1.535 | 2.752 | -1.755 |
| | HR 8: | -2.015 | 1.543 | 2.733 | -1.704 |
| | HR 9: | -1.831 | 1.397 | 2.665 | -1.704 |
| | HR 10: | -1.770 | 1.508 | 2.407 | -1.691 |
| | HR 11: | -1.482 | 1.468 | 1.981 | -1.641 |
| | HR 12: | -1.458 | 1.853 | 1.404 | -1.637 |
| | HR 13: | -1.572 | 2.154 | 1.199 | -1.679 |
| | HR 14: | -1.544 | 2.079 | 1.260 | -1.676 |
| | HR 15: | -1.452 | 1.994 | 1.226 | -1.661 |
| | HR 16: | -1.311 | 1.727 | 1.255 | -1.541 |

*Table 5 – Example of average differences in HR calculated for one single subject*

For each subject a table with 16 lines, one for each HR measured in phase 1, and 4 columns, one for each color which can be selected by the computer in phase 3, is produced. Values are relative to the average difference in HR measured in phase 1 according to the target selected by the computer in phase 3 (table 5). As it will be seen these average differences values in HR will be the statistical units used in the Chi Square tables. Table 5 can also be represented in a graphical form (table 6). Each point corresponds to an average difference value in HR.

It is important to note that Tressoldi's hypothesis that the effect would show only in coincidence with the presentation in phase 1 of the color which would be the target, is not confirmed. In fact, results show (table 6) that the effect spreads on all phase 1, independently from the color which is being shown.

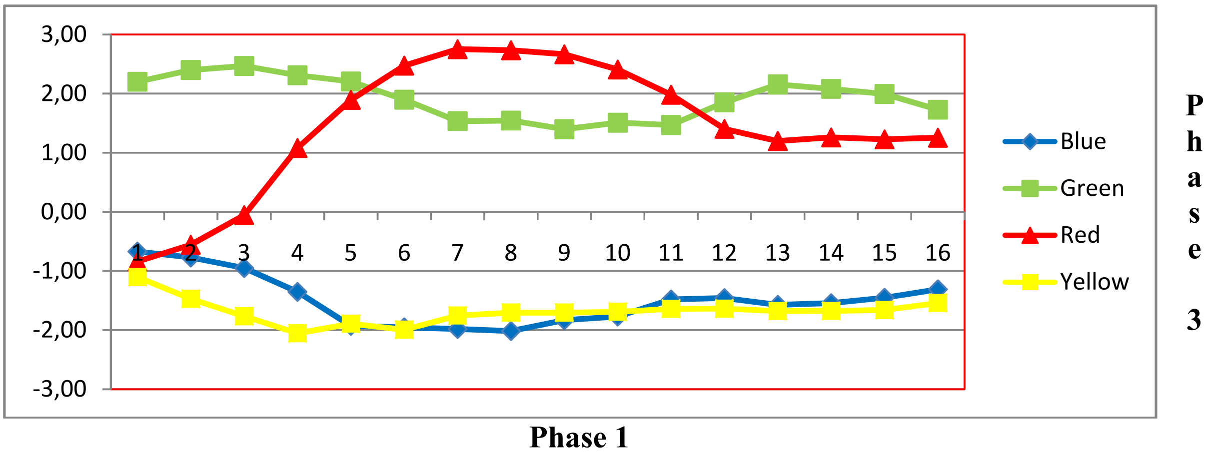



*Table 6 – Graphical representation of table 5.*

*Results of the fourth experiment*

*- Retrocausal effect*

It is possible to study the global retrocausal effect using the Chi Square statistical test which compares observed frequencies with expected frequencies (in the absence of correlation). For this purpose a frequencies table was constructed using 1.5 as a cut off value. Table 7 shows how many comparisons of HR average differences, calculated on the 16 HR measured in phase 1 exceed 1.5 and how many are lower than -1.5.

| ***Frequencies*** | ***Differences*** | | | ***Total*** |
|---|---|---|---|---|
| | **Less than -1,500** | **-1,499 a +1,499** | **+1,500 and more** | |
| **Observed** | 1053 (17,83%) | 3680 (63,89%) | 1027 (18,28%) | 5760 (100%) |
| **Expected** | 781 (13,56%) | 4225 (73,35%) | 754 (13,09%) | 5760 (100%) |

*Table 7 – Observed and expected frequencies in the distribution of average HR differences in phase 1 according to the selection operated by the computer in phase 3 (see table 5).*

Chi Square results in a value of 263.86 which is strongly significant from a statistical point of view if we consider that p<1/1000 starts at the Chi Square value of 13.81.

It is important to note that, because of the statistical techniques which were used, this global retrocausal effect did not show in the previous experiments where it was possible to assess the retrocausal effect only for some colors. It is also important to say that choosing a cut-off point higher than 1.5 the Chi Square value increases.

A sample of 30 subjects participated in this experiment. Each subject was exposed to 100 trials, and for each trial 16 HR were measured in phase 1, for a total of 1,600 HR for each subject. However the value of n (sample used in the data analysis) corresponds to the number of HR average comparisons: 5,760. Compared to the number of HR measured (48,000), 5,760 is a conservative n, a fact which allows to exclude effects due to autocorrelation. The risk of autocorrelation or other possible artifacts linked to statistical data analysis was excluded using fake targets (not shown to subjects, but inserted in the data analysis). Fake targets did not correlate with the HR measured in phase 1.

The same criteria used in order to calculate the global Chi Square, can be used in order to calculate the effect associated to each color (table 8). In table 8 differences under -1.5 and over 1.5 are shown. The effect results to be strong for each color, even if the red and yellow colors show a negative and positive dimension of the effect which is similar; classical statistical techniques which require additive effects would not show the effect on the red and yellow colors, leading to a type II error.

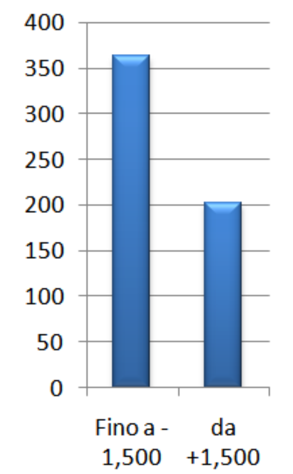
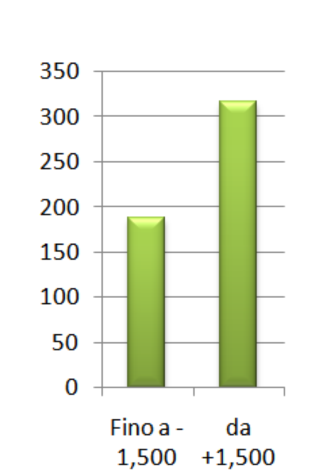
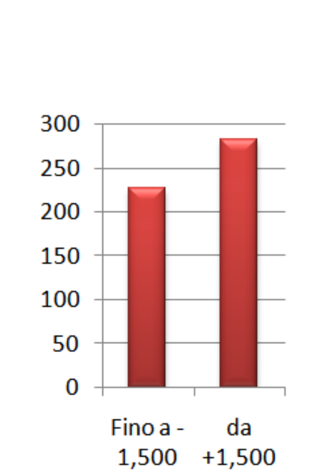
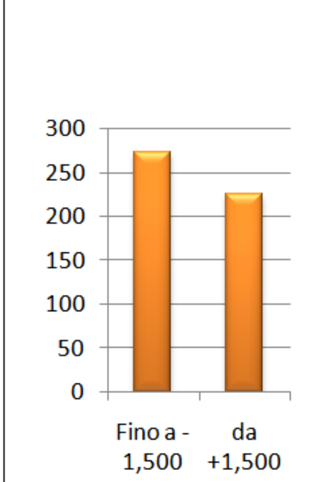
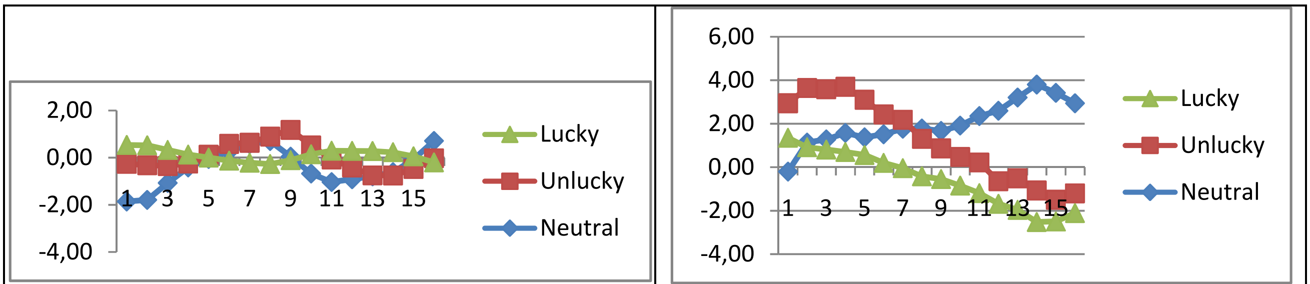
| *Blue* | *Green* | *Red* | *Yellow* |
|---|---|---|---|
|  |  |  |  |
| $p<1/10^{27}$ | $p<1/10^{12}$ | $p<1/10^{13}$ | $p<1/10^{11}$ |

*Table 8 – Positive and negative retrocausal effects for each color. Whereas for the blue color the effect in the form of a decrease in HR is stronger, and for the green color in the form of an increase in HR, for the red and yellow color the effect tends to distribute equally in the positive and negative side, becoming therefore invisible to Student t and ANOVA techniques.*

*- Learning effect*

Graphs in table 9 show the average differences in HR measured in phase 1 according to the choice operated by the subject in phase 2. On the left the graph is relative to the first 33 trials, on the right to the last 33 trials. This graph shows how the differences in HR increase in the last 33 trials and move away from the 0 value (absence of the effect).

The global analysis of the effect carried out with the Chi Square test, shows a learning effect with a probability of $p<1/1000$ in the first 33 trial, whereas in the middle 33 trials no effect is shown and in the last 33 trials the probability is $p<1/10^{22}$.




***First 33 trial*** ***Last 33 trial***

*Table 9 – Graphical representation of the learning effect in one subject*

*- Interaction between the retrocausal and the learning effect*

In the previous experiments, in which the random extractions were balanced, and no lucky and unlucky color existed, the retrocausal effect was constant from the beginning to the end of the experiment.

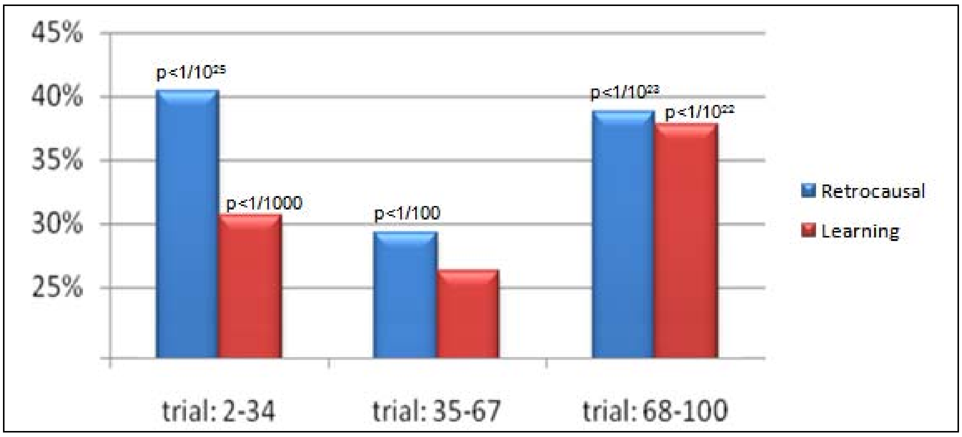



*Table 10 – Interaction between the retrocausal and the learning effect*

In this last experiment a strong decrease in the retrocausal effect is found in the middle 33 trials (p=0,000000000000076) as it is shown in table 10. This strong decrease in the retrocausal effect is interpreted as an interaction between the retrocausal and learning effects.

***Conclusions***

The first experiment showed strong differences in HR measured in phase 1 for the blue and the green colors when selected by the computer in phase 3. The second experiment showed strong differences for all the colors and also when numbers were used. The third experiment showed the absence of the effect when the feedback, the selection operated by the computer, was not shown. The fourth experiment showed the retrocausal effect on all the colors, the learning effect described by Damasio and an interaction between these two effects.

How can these results be interpreted?

According to Fantappiè's Syntropy, anticipated waves would act mainly on the autonomic nervous system, and would be felt as somatic feelings which can be positive, in the form of a feeling of heat (Syntropy = concentration of energy), and negative in the form of cold (Entropy = dissipation of energy). These feelings would help the subject to direct choices towards advantageous aims which are located in the future.

Furthermore, according to Fantappiè, the feeling of life, and therefore consciousness, can be regarded as a direct consequence of anticipated waves, the negative solution of the wave equation, and this could be compatible with Damasio's model. Damasio considers the "background feeling" equivalent to the feeling of life (Damasio, 1999).

However, according to the model of Syntropy, somatic feelings and emotions would be, at least in part, the outcome of *future states*.

Chris King (1996) underlines that the constant interaction between information coming from the past and information coming from the future places life structures in front of bifurcations. This constant antagonism between past and future forces life, at all levels, to operate choices which result in chaotic dynamics. By inserting attractors in chaotic and complex systems ordered figures are generated (fractals). According to King, fractal structures would guide the growth and evolution of living systems, and would also be at the basis of the processes of consciousness.

Going back to the classical problems of the theory of mind, extending the models to the properties of the anticipated waves, and the law of Syntropy, it would be possible to consider:

- **Binding** as a consequence of the cohesive and ordering properties of the law of syntropy.
- **Intuition** as a consequence of the fact that signals coming from the autonomic nervous system allow to perceive our future states guiding us towards advantageous choices.
- **Free will** as a consequence of the dual causality in the form of information coming from the past (learning) and somatic feelings coming from the future (anticipation). Chris King (1989) suggests that this constant antagonism between past and future would force humans into a state of free will and consciousness.
- **Mental causation** as a consequence of the fact that the wave equation has a dual solution: negative (*res cogitans*) and positive (*res extensa*), however both part of the same equation. This would

support Damasio's idea that Descartes committed an error when he divided *res cogitans* from *res extensa*.

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