Original Article

Collapse of the Wave Function? Pre-Stimuli Heart Rate Differences

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Abstract

Analyzing the EPR paradox, Schrödinger concluded that the problem lies in the way time is used in quantum mechanics. The Schrödinger wave equation, which was the focus of most of the discussion surrounding EPR, is not relativistically invariant and treats time in an essentially classical way. For example it assumes that there can be a well-defined "before" and "after" the collapse of the wave function. Once the wave function collapses into a particle, the event is irreversible. On the contrary, when the relativistically invariant wave equation (Klein-Gordon's equation) is taken into account, there is no collapse of the wave function. In this paper a time symmetric interpretation, proposed by the mathematician Luigi Fantappiè in 1941, is presented and four experiments which support this interpretation and challenge the Copenhagen Interpretation are discussed. In Cramer's Transactional Interpretation and in de Beauregard's Advanced-Action Interpretation the EPR paradox disappears when advanced waves are considered to be real physical entities.

Key Words: heart rate differences, pre-stimuli reactions, autonomic nervous system, advanced waves, syntropy

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Introduction

The relativistically invariant version of the wave equation was produced by Klein and Gordon in 1926. In order to turn Schrödinger's wave equation (Ψ) into a relativistically invariant equation Klein and Gordon had to insert the energy/momentum/mass relation (1), obtaining in this way the relativistically invariant wave equation (2).

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$$E^2 = c^2p^2 + m^2c^4 \quad (1)$$

Energy (E), momentum (p), mass (m)

$$E\psi = \sqrt{p^2 + m^2}\,\psi \quad (2)$$

Klein-Gordon's equation depends on a square root which always yields two solutions: one positive and one negative. The positive solution describes waves and causes which propagate from the past to the future (retarded waves), whereas the negative solution describes waves and causes which propagate backwards from the future to the past (advanced waves).

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

Time-symmetric interpretation: the law of syntropy

While studying the mathematical properties of the positive and negative solution of the Klein-Gordon's equation, which can be considered the fundamental equation of the universe, Luigi Fantappiè noted that:

1. The retarded wave's 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 advanced waves solution, which describes waves which diverge from the future to the past and that correspond, for us, to converging waves, are governed by a law symmetric to entropy which Fantappiè named syntropy (from Greek, *syn*=converge, *tropos*=tendency), and 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 the formulation of his "*Unitary theory of the physical and biological world*" (Fantappiè, 1944) and to the hypothesis that life feeds on advanced waves.

Similarly to Fantappiè, in 1986 John Cramer, physicist of the Washington State University, presented the Transactional Interpretation of quantum mechanics. In this interpretation the formalism of quantum mechanics remains the same, but the difference is how this formalism is interpreted. Cramer was inspired by the absorber-emitter model developed by Wheeler and Feynmen, which used the dual solution of Maxwell's equation and extended this model to the well known Klein-Gordon's equation. Cramer found that the dual solution of this equation allows to explain in a simple way the dual nature of matter (particles and waves), non locality and all the other mysteries of quantum mechanics and permits to unite quantum mechanics with special relativity. According to Cramer, the transaction between retarded waves, coming from the past and advanced waves, coming from the future, gives birth to a quantum entity with dual properties wave/particle. The wave property is a consequence of the interference between retarded and advanced waves; the particle property is a consequence of the point in space where the transaction takes place. The Transactional Interpretation requires that waves can really travel backwards in time. This assertion is counterintuitive, as we are accustomed to the fact that causes precede effects. It is therefore important to remember that the Transactional Interpretation takes into account special relativity, which describes time as a dimension of space, in a way which is totally different from our intuitive logic. Cramer underlines that the Interpretation of Copenhagen treats time in a classical Newtonian way and solves its contradictions using the role of consciousness in a mystical way.

Autonomic nervous system and pre-stimuli reactions

According to the Copenhagen Interpretation, which treats time in the classical way, no advanced effects are possible. However, in 1981 Ulisse Di Corpo suggested that if vital processes feed on syntropy (advanced waves) the parameters of the autonomic nervous system (skin conductance and heart rate), which supports vital functions, should react in advance to stimuli (Di Corpo, 1981; 2007). If this hypothesis is true it would support the

Time Symmetric Interpretation and falsify the Copenhagen Interpretation of quantum mechanics.

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. Anticipatory pre-stimuli reactions, in the parameters of skin conductance and heart rate, have been reported in several studies:

1. The first experimental study was produced by Radin in 1997 and monitored heart rate, skin conductance and fingertip blood volume in subjects who were shown for five seconds a blank screen and for three seconds a randomly selected calm or emotional picture. Radin found significant differences, in these autonomic parameters, preceding the exposure to emotional versus calm pictures. In 1998 Bierman replicated Radin results confirming the anticipatory reaction of skin conductance to emotional versus calm stimuli and in 2003 Spottiswoode and May, of the Cognitive Science Laboratory, replicated Bierman and Radin's experiments performing controls in order to exclude artifacts and alternative explanations. 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 parameters of the autonomic nervous system (McDonough *et al.,* 2002; McCratly *et al.,* 2004; May and Vassy, 2005; Radin, 2005).
2. In the article "*Heart Rate Differences between Targets and Nontargets in Intuitive Tasks*", Tressoldi and coll. (Tressoldi, 2005) describe two experiments which show anticipatory heart rate reactions. 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, measured in phase 1 during the presentation of target and non target pictures, was obtained (t = 2.42, p=0.015), in the second experiment the heart rate difference was 0.57 HR (t = 3.4, p=0.001).
3. Studying neurological patients affected by decision making deficits, Antonio Damasio (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. These subjects show a behavior which can be described as "*shortsighted toward the future*". Damasio suggested the somatic markers (SM) hypothesis, according to which emotions are part of the network of reasoning and constitute a part of the decision making process, instead of opposing it. Damasio describes SM 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.*" SM can be measured as reactions of the autonomic nervous system using the parameters of skin conductance, heart rates and body temperature. The Iowa Gambling Task (IGT), which was devised by Bechara and Damasio (Bechara and Damasio, 2006) in order to simulate real decision making processes, shows 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 the deck (lucky or unlucky) from which to extract the card. Damasio interprets the anticipatory reaction of skin conductance as an effect of learning.

Experiments

The authors of this paper conducted four experiments in order to replicate and control Tressoldi's results and study the interaction between Fantappiè's anticipatory effect and Damasio's learning effect. A detailed description of these experiments can be found in the PhD thesis of Antonella Vannini "*A Syntropic Model of Consciousness*" (Vannini, 2010).

Choice of the heart rate frequency device

Tressoldi's experimental design requires perfect synchronization between measurements of HR and the presentation of stimuli on the computer screen. An assessment of the devices used to measure the parameters of the ANS system was carried out and problems were found with most laboratory devices:

- Many devices use a different clock from the one used by the computer during the execution of the experiment.
- The information saved on the file is not corrected according to the delay of the measurements.

Producers and distributors of laboratory devices have been contacted, but all the products used built-in software which did not satisfy the synchronization requirements of the experiment. Furthermore the producers of these devices did not agree to provide the software keys which would allow the development of personalized software and the direct acquisition of heart rate data. The laboratory devices which have been assessed always presented these limits: proprietary software which did not allow accessing directly the device. In order to try to overcome this limit, a laboratory in North Italy provided some devices, and for each one the impossibility to establish a satisfactory synchronization between the device and the stimuli which were presented on the PC monitor was assessed.

Tressoldi was contacted and he confirmed the same difficulty. In his department in Padua (Italy) the problem was solved by a technician who himself built the heart rate devices. This solution was not possible in the department of psychology in the University of Rome. The assessment was therefore extended to devices used outside the experimental laboratories, in the field of sports training. Most devices showed the following limits:

- Heart rate measurements are stored in a wrist watch, using in this way a different clock from the one used to conduct the experiment.
- The information is stored without any compensation for the delay due to the measurement.
- Some devices showed loss of data.

After a long evaluation, the "home training" device produced by SUUNTO 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 same clock of the experiment.

The SUUNTO heart monitor device measures the heart 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 relative to the average value during the second and is saved compensating the delay due to the time which is necessary to perform the measurement and to process the information. The heart rate data time, saved in the file, is therefore perfectly synchronized with the measurement performed. The heart rate information is saved as an integer number, without any decimal values.

The SUUNTO "home training" device has been developed in order to monitor sports training activities and can be used in the most extreme conditions, for example underwater. It does not require 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. The only limit was observed in cold climates when loss of data was observed in some subjects. These subjects were excluded from the sample.

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 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) the measurement disappears after 5 seconds; when the signal is reactivated the measurement reappears after 2 seconds.

Data saved in the file showed that when the signal is deactivated (moving the device away from the chest of the subject) the last measurement is kept for 3 seconds; when the signal is reactivated the *measurement reappears immediately*. Whereas the delay in the measurements shown in "real time" on the PC monitor is approximately of 2 seconds, in the data file the delay is compensated and the measurement is associated to the exact time.

Pseudorandom and random

In order to test anticipatory effects the fundamental condition is that the selection operated by the computer in phase 3 is unpredictable. 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. 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 sequence to be irregular and not repetitive.
- *Absence of order*. In random sequences no type of structure or order can be detected.

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.

Computer languages usually use the word *random* to identify the instruction which starts the algorithm for random selections of numbers. In this experiment the Delphi-Pascal programming language was used to develop the stimuli presentation software. Delphi-Pascal has a predefined random sequence which can be accessed through a pointer which can be defined by the user or by the value of the built-in clock. Delphi-Pascal uses the following instructions:

- *Randomize* reads the value of the built-in clock and uses this value as the pointer to the predefined random sequence;
- *Random* reads the value of the predefined sequence using the pointer selected by the randomize instruction.

The user can also define a personalized pointer. This option is generally used in software which encrypts information. Utilizing the same pointer the selection of random numbers from the predefined random sequence will always be the same.

In order to obtain different random sequences the *randomize* procedure is used;

this procedure reads the built-in clock of the computer in order to select a pointer. The problem arises when the *randomize* procedures are 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 the selections, even if performed using a predefined random sequence, are all determined by the first value: the first value determines the second value, 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 anticipation, and which are based on the assumption of unpredictability, a pseudo-random sequence would inevitably be considered an artifact in the experimental design. Luckily the solution to this problem is incredibly simple. The problem arises from the fact that the duration of the loops is always the same. In order to overcome this problem, obtaining in this way pure random selection, 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 is asked to press a button corresponding to the color that he/she thinks the computer will select, the reaction time of the subject is always unpredictable. In this way, the unpredictable reaction time of the subject makes the loop time become unpredictable, and the value selected from the built-in clock of the computer becomes independent from the other values previously selected. 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 have been conducted in this study, the subject was asked to operate a choice; the reason for this request was that of restoring the independence of the terms in the random selection operated by the computer.

Stimuli

As soon as the SUUNTO heart rate device was chosen, the experimental design developed by Tressoldi was tested. Tressoldi's design is divided in 3 phases:

1. Stimuli are shown individually on the PC monitor and heart rate is measured.
2. Stimuli are shown together on the PC monitor and the subject tries to guess which one will be selected by the computer.
3. The computer selects one of the 4 stimuli (target stimulus), using a random procedure, and shows it on the PC monitor full screen (feedback).

The first experiment was conducted using software developed in Visual Basic 2005. The following experiments used software developed in Delphi Pascal which allowed a better control of the computer hardware and a more precise synchronization of the presentation of the images.

The hypothesis is that, in the event of anticipatory effects, heart rate measurements in phase 1 (the presentation phase) should be significantly different between target images (those which will be chosen by the computer in phase 3) and non target images (those which will not be chosen by the computer).

The preliminary experiments (not discussed in this paper) used stimuli made of black bars placed horizontally, vertically and diagonally on a white background. Data analysis did not show any significant difference between targets and non targets. The hypothesis was therefore analyzed in more depth and it was noticed that the central element is that anticipation should be mediated by emotions/feelings and, therefore, in order to see differences between target and non target stimuli, images should arouse emotions.

Following this indication it was decided to use 4 elementary colors: blue, green, red and yellow. Using these colors, a strong difference in the heart frequencies between target and non target stimuli was observed. The difference was observed within the same color, while considering all the colors together differences were not observed. It was therefore decided to conduct the experiments using these 4 elementary colors as stimuli. Experimental trials (Table 1) are divided in three phases:

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).

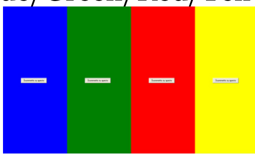
Phase 1 *Presentation of colors and measurement of heart rate*				**Phase 2** *Choice*	**Phase 3** *Random selection*
Blue	Green	Red	Yellow	Blue/Green/Red/Yellow	Red
					***Target***
4 seconds	*4 seconds*	*4 seconds*	*4 seconds*		***Feedback***

Table 1. Phases of an experimental trial

During the experiment two software are active:

- The Training Monitor 2.2.0, produced by SUUNTO, which processes heart rate information arriving from the heart rate thorax belt. This program associates each heart rate frequency to the date and second of the measurement and stores the data in a file and directory created by the SUUNTO software.
- The second software was produced using Delphi Pascal for the presentation of stimuli and the conduction of the experiment. Stimuli are presented exactly at the turn of the second, with the precision of milliseconds, obtaining in this way a perfect synchronization between the data stored by the SUUNTO software and stimuli presented by the computer. This last program saves data in a different directory from the one used by the SUUNTO program. Each event is associated with the exact moment of its happening (year, month, day, hour, minute, second and millisecond).

Only at the end of the experiment the two files are merged together using the time information.

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 and the total HR sample was therefore of 5,760 measurements. Statistical analyses compared HR measured in phase 1 when the color shown was target and non target. Globally no difference between HR associated to targets (80.94 average HR value) and to non targets (80.97) was observed. However, when statistical analyses were carried out within colors, strong differences were observed for the blue ($t=10.74$, $p<0.001$, HR difference 2.15) and green ($t=8.81$, $p<0.001$, HR difference 1.85). A second analysis was performed using the Chi Square test. Statistical significance was calculated comparing the number of measurements which were over or under the baseline of the color. Also in this case strong differences were observed with Chi Square values over 30 for the blue and green colors ($p<0.001$ significance is reached with Chi Square values of 10.8).

The choice operated by the subject in phase 2 was not included in the data analysis. 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, is expected by chance. It is also important to underline that 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, others showed strong results in the opposite direction.

Experiment number 2

The first experiment raised the following questions: does the effect show only with the blue and green colors? Does the effect arise only with colors? Does the effect occur only when the computer shows the feedback in phase 3? In order to answer these questions the *second experiment* was devised in 5 blocks of trials. In the first 3 trials the sequence of presentation of colors varied, in order to answer the first question; in the last trial numbers were used instead of colors in order to answer the second question and in the fourth trial feedback was not shown in order to answer the third question. The data sample was of 9,200 HR (23 subjects x 100 trials x 4 stimuli). Data analysis showed the effect ($p<0.001$) associated to red and yellow targets in the first trial, to blue and yellow targets in the second trial and to blue and green targets in the third trial. The effect was also observed with numbers and was absent when the computer did not show the feedback. The apparently random association between the effect (HR differences) and the color targets led to the introduction of a series of controls. The main one consisted in the use of fake targets. Fake targets are randomly selected targets added during data analysis in order to assess if statistical significance values could happen by chance. Data analyses showed that these "fake targets" were not associated with statistically significant HR differences; consequently results had to be considered real.

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. The data sample was of 3,200 HR (8 subjects x 100 trials x 4 stimuli), 2,596 HR were associated to feedbacks while 604 were not associated to feedbacks. The effect showed ($p<0.001$) only in the 2,596 HR associated with feedbacks, for the blue and yellow colors. The feedback of the computer, in phase 3, can therefore be considered the cause of HR differences measured in phase 1 (Figure 1).

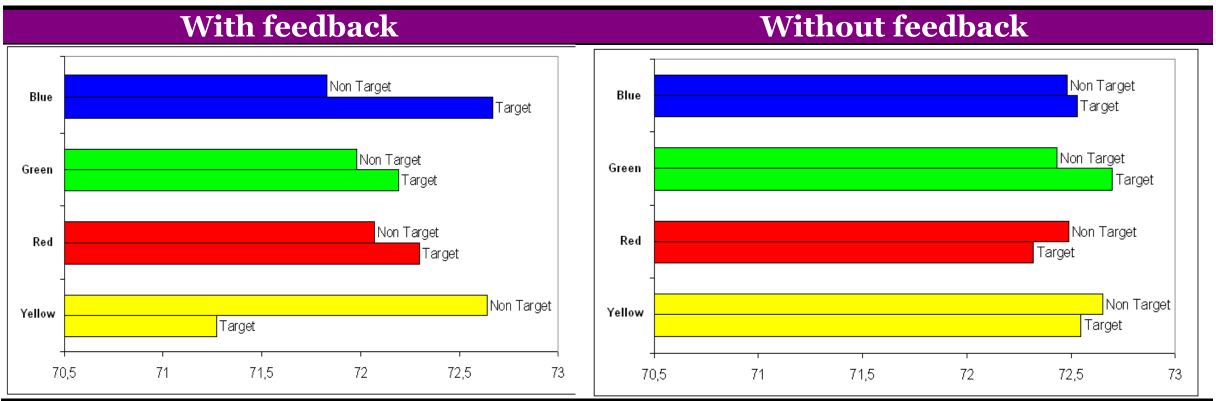


Figure 1. Average heart rate values

Experiment number 4

The rationale of the *fourth experiment* was to dissociate Fantappiè's anticipatory effect from Damasio's learning effect. Trials were identical to those used in the first experiment, but colors had different probabilities of being selected: the "lucky" color had a 35% chance of being selected, the unlucky color a 15% chance and the 2 neutral colors a 25% chance. The anticipatory effect was assessed comparing HR measured in phase 1 according to the target selected in phase 3. The learning effect was assessed comparing HR measured in phase 1 according to the quality of the color chosen by the subject in phase 2 (lucky, unlucky and neutral). Trials were repeated 100 times per subject.

In the previous three experiments, the apparently random way in which the effect showed only for some target colors suggested the presence of artifacts. Controls were therefore performed and, when analyzing subjects singularly, the effect appeared for all colors. The apparently random way in which the effect showed, was explained as a consequence of the fact that subjects increase or decrease HR differently for each target color. ANOVA and Student t require additive data, consequently adding opposite effects results in a null effect. It was therefore decided to compute HR differences only within subjects and to use Chi Square and the exact test of Fisher to assess the statistical significance of the effect.

HR differences were calculated within subjects and within the first 33 trials, the middle 33 trials and the last 33 trials. A total of 5,760 HR differences between target and non target colors were available for data analysis (4 target colors x 16 HR measured in phase 1 x 3 groups of trials x 30 subjects = 5,760 HR differences). Table 2 compares the distribution of these HR differences with the expected distribution, in the event of a null effect; a Chi Square of 263.86 was obtained ($p<0.001$ starts at 13.81). The risk of statistical artifacts was excluded using fake targets (not shown to subjects, but inserted in the data analysis) which obtained Chi Square values under 13.81.

It is important to note that, because of the statistical techniques used in the previous experiments, this global retrocausal effect did not show and it was possible to assess the retrocausal effect only for some colors. Data analysis, conducted for each color, obtained a statistical significance of the effect of $p=1/10^{27}$ for blue, $p=1/10^{12}$ for green, $p=1/10^{13}$ for red and $p=1/10^{11}$ for yellow (figure 2).

	Differences between target and non target HR			*Total*
	-1.5 HR and less	From -1.4 to +1.4	+1.5 HR and more	
Data from the experiment	1,053 (17.83%)	3,680 (63.89%)	1,027 (18.28%)	5,760 (100%)
Expected distribution	781 (13.56%)	4,225 (73.35%)	754 (13.09%)	5,760 (100%)

Table 2. Distribution of HR differences between target and non target stimuli

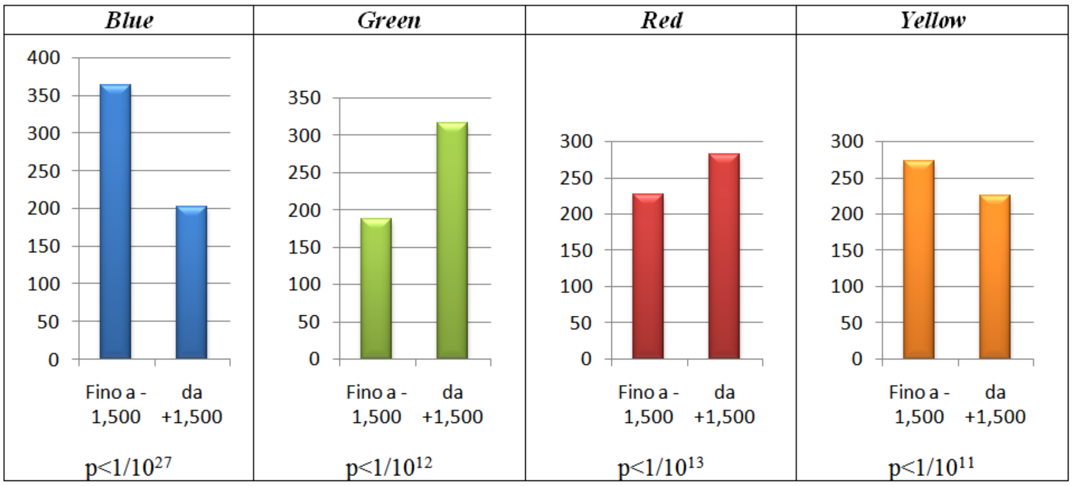


Figure 2. Positive and negative retrocausal effects for each color; for the red and yellow color the effect tends to distribute equally in the positive and negative side, becoming therefore invisible to *Student t* and ANOVA.

In this experiment data analysis differs from previous experiments as the average difference values of HR are calculated only within each 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 3 and figure 3).

		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 3. Example of average differences in HR calculated for one single subject

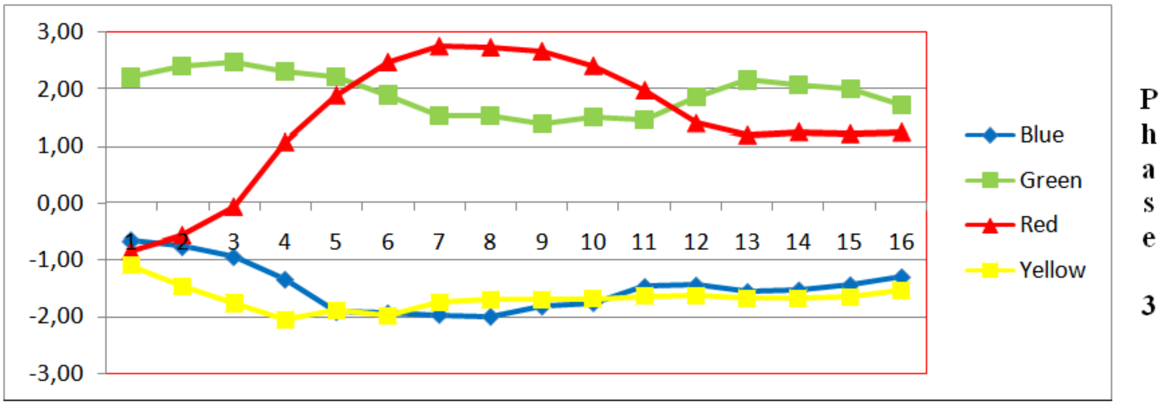


Figure 3. Graphical representation of table 3

In order to study the learning effect, differences in HR were divided according to the quality of the color chosen by the subject in phase 2 (lucky, unlucky and neutral color). A total of 4,320 HR differences were available for data analysis, (3 color qualities x 16 HR measured in phase 1 x 3 groups of trials x 30 subjects = 4,320 HR differences). Results showed a learning effect of $p=1/10^3$ in the first 33 trials, a null effect in the middle 33 trials and a $p=1/10^{22}$ effect in the last 33 trials.

In previous experiments, target selection was balanced, no lucky and unlucky color existed, and results showed that the anticipatory effect was constant from the beginning to the end of the experiment. In this last experiment a strong decrease in the anticipatory effect was found in the middle 33 trials ($p=1/10^{15}$), together with a decrease in the learning effect. These results were interpreted as an interaction between anticipatory and learning effects.

Control of artifacts

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.

The control of artifacts was 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 presented in phase 1: 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 rate 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 may not be aware. In the last experiment statistical data analyses were performed using non parametric techniques, because, as it was shown, the requirements for the use of 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 were considered and non parametric statistical techniques, based on the comparison of frequencies, were used. 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, which were observed, 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. Since it is rarely possible to replicate the experiments, the doubt of data manipulation remains as long as the same results are not replicated by other researchers. Experiments described in this paper are easy to replicate and the heart rate measuring device can be easily bought. However it is important to note that similar results have been observed independently by several researchers, among whom Radin, Bierman and Tressoldi.

Measurement errors

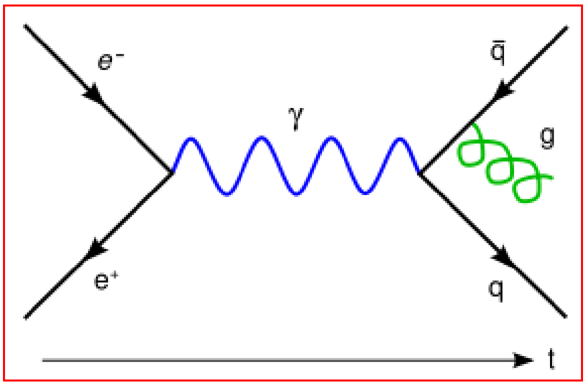
The SUUNTO heart rate device, used in these experiments, has a range which goes from 30 heart rate beats per minute to 230 heart rate beats per minute, with a measuring error of ±0.5. One of the fundamental laws about measuring errors is that errors distribute randomly around the mean values. This law known as the law of the sampling distribution of means states that "*the mean of the means of samples, coincides with the mean of the population of the samples*." 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; opposite measurements errors, when added, result in a null error, eliminating the distortion due to measuring errors. In the experiments conducted in this study, the number of measurements performed allows to consider significant mean values up to the fourth decimal. Anyhow, in the last experiment data analysis has been performed using non parametric techniques (Chi Square and Fisher's exact test). As it was seen these techniques lead to extremely significant results, and do not require the precision of measurements which might be needed when the analysis is conducted using parametric techniques (ANOVA and t of Student). Furthermore, data analysis performed on single subjects shows that variations in heart rate measurements between target and non target stimuli can be very strong, and this fact eliminates any requirement for a measurement device which can be precise up to the hundredth of a heart beat. Generally speaking, the problem of the measuring device is assessed when no statistical differences are observed and the problem could be related to the measurement device. In this study strong and statistically significant effects are observed and these effects are replicated each time.

Discussion

Results of the 4 experiments seem to support the Time Symmetric Interpretation and falsify the Copenhagen Interpretation of quantum mechanics, since they violate the classical notion of Newtonian time and are therefore totally incompatible with the Copenhagen Interpretation. Roger Penrose in his book "The Road to Reality" (Penrose, 2005) underlines that usually physicists tend to reject as "unphysical" 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. Even if Penrose chose to reject the negative solution of the Klein-Gordon equation, he states that this refusal is a consequence of a subjective choice, towards which other physicists have different opinions. Penrose dedicates nearly 200 pages of his book to the paradox of the negative solution. According to Penrose it is important that the value of E is always positive because negative values of E lead to catastrophic instabilities in the Standard Model of sub-atomic physics. "*Unfortunately in relativistic particles both solutions of the equation need to be considered as a possibility, even a non physical negative energy has to be considered as a possibility. This does not happen in non relativistic particles. In this last case, the quantity is always defined as positive, and the embarrassing negative solution does not appear*." Penrose adds that the relativistic version of Schrödinger's equation does not offer a procedure in order to exclude the negative solution. In the case of a single particle this does not lead to any real problem, however when particles interact, the wave function cannot yield only the positive solution. This creates a conflict with the law of classical causation. In order to remove the embarrassing negative solution, in 1931 Dirac suggested an hypothesis which Penrose describes simply as crazy. Dirac used Pauli's principle, according to which two electrons cannot share the same state, to suggest that all states of negative energy are occupied, thereby forbidding any interaction between positive and negative states of matter. This ocean of negative energy which occupies all positive states is called *Dirac sea*. The Standard Model of physics is based on this assumption.

Even if classical physics rejects the negative solution of energy and the possibility of retrocausality, several respected scientists have worked and are working on this possibility.

A classical example is Feynman's diagrams of electron-positron annihilation, according to which electrons are not destroyed by the contact with positrons, but the release of energy is caused by electrons changing direction in time and becoming positrons. When Feynman's diagrams are interpreted they imply necessarily the existence of retrocausality (Feynman, 1949). Feynman has also used the concept of retrocausality to produce a model of positrons which reinterprets Dirac's hypothesis on the sea of negative energy occupying all possible states. In this model, electrons which move backwards in time would acquire positive charges (Wheeler, 1945).



Yoichiro Nambu has applied Feynman's model to the processes of annihilation of particle-antiparticle couples, arriving at the conclusion that it is not a process of annihilation or creation of couples of particles and antiparticles, but simply a change of the time direction of particles, from the past to the future or from the future to the past (Nambu, 1950).

Costa de Beauregard used the concept of retrocausality in order to explain entanglement (de Beauregard, 1977) and in 1986 John Cramer, physicist at the Washington State University, formulated his Transactional Interpretation, inspired by the absorber-emitter model developed by Wheeler and Feynman.

Until the XIX century, time was considered to be irreversible, a sequence of absolute moments. In 1954 the philosopher Michael Dummet showed that there is no philosophical contradiction in the idea that effects can precede causes (Dummet, 1954). More recently, Jan Faye of the University of Copenhagen argued that even if it will not be possible to organize time travel at the macroscopic level, this fact does not exclude that retrocausality can act at other levels (Faye, 1994), and Jeanne Peijnenburg uses the concept of retrocausality in order to describe and redefine the cognitive processes of perception (Peijnenburg, 1999).

Einstein's relativity started a new description of reality which is symmetrical in respect of time: on one side energy which propagates from the past to the future, on the other side energy which propagates backwards in time from the future to the past, and which we experience as *attractors*. Einstein used the term *Übercausalität* (supercausality) to refer to this new model of causality.

In the paper "A novel interpretation of the Klein-Gordon equation", Wharton concludes that

> "It is obvious that quantum mechanics is counter-intuitive, but it must be counter-intuitive for a reason – some human intuition that fundamentally contradicts some physical principle. One example of this would be the well-known conflict between our directed experience of time and the more symmetric treatment of time in fundamental physics. If the counter-intuitive aspects of quantum mechanics could be explained via classical fields symmetrically constrained by both past and future events, then it would be a mistake to reject such a solution based solely on our time-asymmetric intuitions." (Wharton, 2009).

If this time-symmetric interpretation is correct, it will probably be necessary to rewrite part of the *Standard Model* of physics.

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