Laboratory Demonstration of Retroactive Influence in a Digital System

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Abstract. Retrocausation has been postulated in physical systems and observed in animate systems. The experiments described here extend methods used in human experiments to systems that are inanimate. One random-event generator, the controller-REG, was used to shut off a second REG, the subject-REG, at a random time. The output of the subject-REG was accumulated over several runs, each consisting of hundreds of trials, to look for a change in the randomness of its output bit stream in advance of the subject-REGs shut off. For the first three runs large changes were observed during the last second before shut off, changes of approximately 1 bit in 40 that exceeded odds against chance of 1 million to 1. Variations and later an exact replication of the early results failed to show the changes observed in the first three runs. This failure to replicate is an indication that there is an additional uncontrolled variable that must be taken into account, quite possibly the intention and enthusiasm of the experimenters. That addition leads to the question as to whether the subject-REG was subject to advance influence from its impending shut off, or instead whether its output was in a superposition of different states until the operator observed the results. The observation would then have caused a collapse of the superposition into a fixed state, like the collapse of quantum mechanical wavefunction. In either case, a retroactive influence was clearly in evidence.

Keywords: retrocausation, random event generator, intention, psi, precognition
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INTRODUCTION

The existence of retrocausation has been postulated in several different domains. One is quantum mechanical, where processes are affected not just by initial conditions, but also by final conditions [1]. An extension of Wheeler-Feynman absorber theory [2] is the transactional interpretation, in which quantum interactions are affected by both forward going (retarded) and backward going (advanced) waves [3]. These interpretations of quantum mechanics are controversial. Experimental verification is challenging because the effects are either what is generally observed, but interpreted nontraditionally, or difficult to obtain. For example, attempts to measure advanced pulses as small as one part in $10^{-11.5}$ of the power of the source pulses were carried out, but none were observed [4] [5].

On the other hand, there is substantial experimental evidence for retrocausation involving the intention of a living system, but there is no accepted or predictive theoretical understanding. We can consider precognition a form of retroactive

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influence in which the event acts backwards in time on the receiver of the precognition or the consciousness of the receiver can reach forward in time to detect an event. Laboratory studies include over 100 published studies by 1989 [6]. Some of the notable more recent studies include experiments in which subjects were physiologically retroactively influenced a few seconds in advance of seeing stimulating images [7] [8], and hearing startling sounds [9], and in which subjects exhibit well-established psychological effects to stimuli provided after the measurement of the response [10].

The living system does not have to be human to produce precognitive effects. In 1967 Morris observed the degree of activity of goldfish before they were scooped out of the water in a net, and found a significant change just before the scooping [11]. Even earthworms have shown evidence for anticipation of randomly time acoustical vibrations [12]. More recently finches have exhibited anticipatory alarm in advance of being shown a video clip of a crawling snake [13].

This evidence for retrocausal effects in simpler living systems leads to the question of whether sentient life forms are required at all, or whether an appropriately structured study with purely inanimate systems would show similar effects. Fully deterministic systems with fixed initial conditions would not be subject to retrocausation because their precise behavior could be described precisely without any reference to the retrocausal stimulus. Therefore an element of uncertainty must be introduced to allow for the retrocausal effects. We have set up a digital system – using random-event generators (REGs) to provide the needed uncertainty – that mimics the operation of some of the precognition experiments. The goals are to observe retrocausal effects, and to determine whether these effects are independent of interactions with living systems.

For retrocausation to be consistent with currently accepted physical law, it cannot violate the second law of thermodynamics. In particular, if the entropy of the receiver of the retrocausal influence were to decrease because of its interaction with the later-acting agent an entropy gap would appear [14]. During this gap between the time of the response of the receiver and the action of the agent the total entropy of the agent-plus-receiver would decrease in forward-going time. To avoid a violation of the second law this gap cannot appear, which means that if the retrocausal influence somehow reduces the entropy of the receiver, then the generation rate of new entropy by other process in the receiver must be sufficient to at least balance that decrease.

The very possibility that retrocausation could exist is controversial. From a logical perspective the bilking (or intervention) paradox, in which one intervenes to eliminate a subsequent cause after a preceding effect has occurred, appears on the surface to show that retrocausation is logically impossible [15]. In fact, this is not a true paradox. As long as there is some noise or information entropy in the retrocausal transmission, bilking can be avoided [16]. Retrocausation does not have to be an all-or-nothing process. The greater that the uncertainty is in the agent's knowledge of the outcome of the prior event, the larger his effect on that event can be.

EXPERIMENTAL DESIGN

Set Up

In the experiments one REG, the "controller-REG," is used to shut off the power to a second REG, the "subject-REG," at a random time. The main objective is to monitor the bit stream of the subject-REG before it is shut off to see if its output deviates from being purely random in advance of its being shut off.

As shown in Figure 1, two Psyleron REGs were connected to a computer (Dell Vostro 460 with four 3.2 GHz CPUs and 6 GB RAM, running Windows 7) through USB ports. The subject-REG provided a stream of random bits that formed the data set for each trial. The wire in the USB line that provided power to the subject RNG passed through a relay. When the controller-REG provided the designated output, the computer signaled the relay through a serial port to shut off the power to the subject-REG. The two REGs were placed approximately a meter apart, to avoid potential electromagnetic interaction between them (although none was observed even when they were placed in contact with each other).

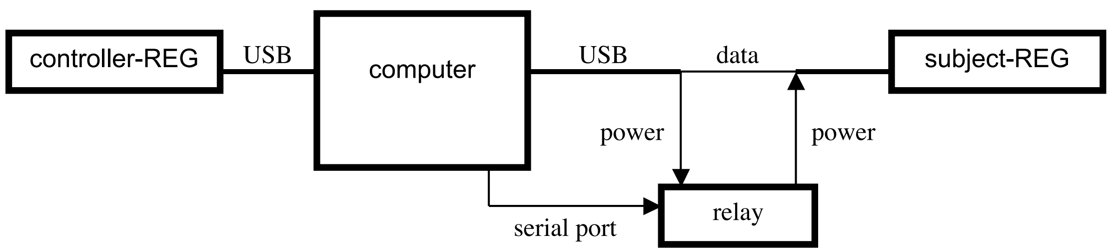

FIGURE 1. Experimental set up. The controller-REG determines when power to the subject-REG is to be shut off.

Procedure

A visual C# program controlled the peripherals and read the data, consisting of random bits from the controller-REG and subject-REG. For the main experiments the data rate from the REGs was 40 bits per second. At the outset of each trial, the controller-REG output was ignored for two seconds to establish a baseline output from the subject-REG. After this period the output of controller-REG was monitored. If its output for exceeded 50% 1's for four consecutive seconds, the computer sent a signal through the serial port for the relay to open for 100 ms. This was sufficient to shut off the subject-REG. Immediately after shutting off power to the subject-REG, i.e., within one bit period of 25 ms, the subject-REG ceased sending any data to the computer. Each bit was stored in the computer along with a time stamp. Multiple time stamp checks were performed to ensure that the recorded times for output of both REGs and the output to the relay were accurate.

A trial is defined as one period between when the subject-REG started sending out data to the time when it was shut off. For the main experiments, the period for each trial varied, with an average time of approximately 20 seconds. A run consisted of a set of roughly 100 to 1000 trials. The number of trials in a run was often determined by the time available, with most of the runs taking place over night. None of the results were observed until both the test and control runs were completed.

Each test run was followed by a control run. The operation of the control runs was identical to the test runs except that the serial port wire to the relay was disconnected. The result was that the subject-REG was never shut off, but times at which it would have been shut off were recorded as in the test runs.

In analyzing and plotting the data only those trials that were at least 15 seconds were used. The data from the first two seconds after the subject-REG resumed sending data, i.e., four seconds after shut off, was ignored, to make sure that the REG had time to stabilize. For each run the numbers of test and control trials were approximately equal, within ±0.5%, but varied because of the random length of each trial. The smaller of those two numbers determined the number of trials analyzed, and the excess trials were not used. The data were analyzed and viewed on a computer display after both entire runs, test and control, were completed.

RESULTS

To analyze the result all the trials were normalized in time to the subject-REG shut off time, providing data set from that time backwards. The data over all trials for each bit period (usually 25 ms) in each run were added together.

Displaying the results by showing the output bit stream as a function of time yielded plots in which it was difficult to observe any trends. Therefore we added a number of bit periods together over a window in time. This window was then swept from the shut off time backwards through the time period over which all the trials yielded data. The number of bits in a window was not crucial. The larger the window, the smoother the data appears as a function of time. Smaller windows result in better the time resolution. We chose 11 bit periods per window as a compromise. For each run we computed statistical confidence intervals, as described in the Appendix.

As a background check we tabulated the free-running output for one of the Psyleron REGs. After 5000 trials it produced a Gaussian distribution and standard deviation that were indistinguishable from expectation for a truly random source.

After some initial runs to test the apparatus and procedure the first major test run was carried out. This run, Run #1, consisted of 613 test trials and 613 control trials. The results are plotted in Figure 2.

As expected, the control run shows fluctuations throughout the time period before shutoff, some of which extend beyond the horizontal lines at averages values of 0.486 and 0.514, corresponding to a 99% confidence interval. There is no pattern evident in these fluctuations. In contrast, the test run curve dives below the line at 0.477 (99.99% confidence) for much of the last second before shut off, and at no other time. This corresponds to roughly one more 0 bit than expected by chance in every 40 bits, and an effect size (defined in the Appendix) of approximately 0.05.

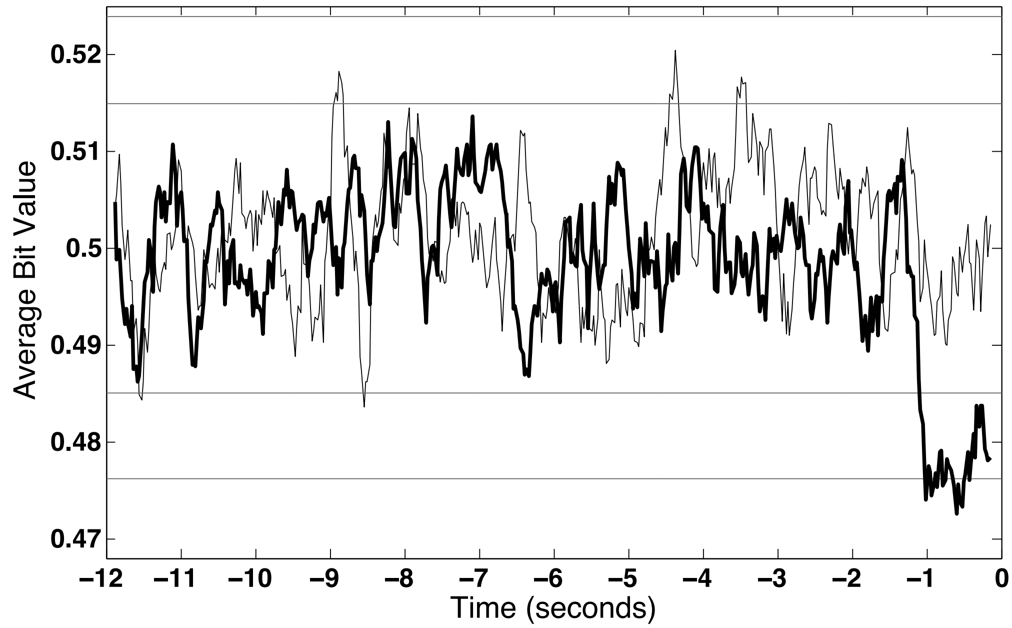

FIGURE 2. Run #1 average bit value produced by the subject-REG as a function of time before shut-off. The test (thick line) and control (thin line) runs consisted of 552 trails each. The average is over an 11-bit window, centered at the nominal time, and scanned across the time period before shut off. The subject-REG provided 40 bits/sec. The closer-in horizontal lines correspond to 99% confidence intervals (two-tailed) and the lowest horizontal line corresponds to the 99.99% confidence interval (two-tailed).

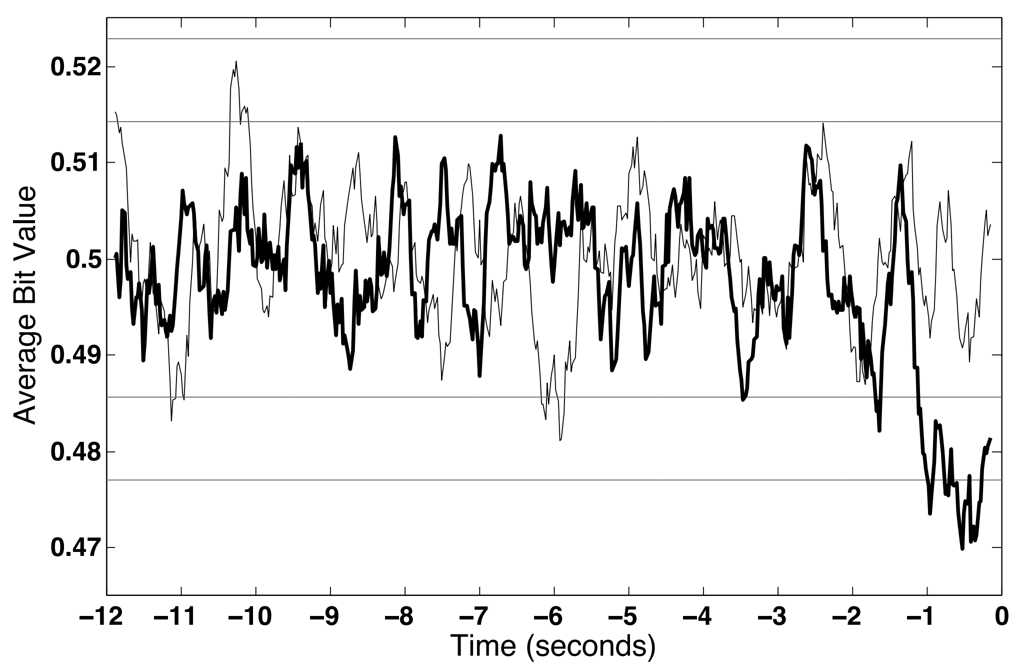

FIGURE 3. Run #2 average bit value produced by the subject-REG as a function of time before shut-off, carried out two days after Run #1. Both the test (thick line) and control (thin line) runs consisted of 600 trails. Other information is the same as that given in the caption of Figure 2.

Run #2, a replication of Run #1, was carried out two days later. It consisted of 600 test trials and an equal number of control trials. The results are plotted in Figure 3. Although the fluctuations in Run #2 are different from those in Run #1, the main features are the same. Again the test run curve dives below the 99.99% confidence level line for much of the last second before shut off, and at no other time. Again, this corresponds to roughly one more 0 bit than expected by chance in every 40 bits. Run #3, a second replication of Run #1, was carried out one day after the first replication. It consisted of 578 test trials and 578 control trials. The results are plotted in Figure 4. Once again, the main features and the size of the effect are consistent with Runs #1 and #2.

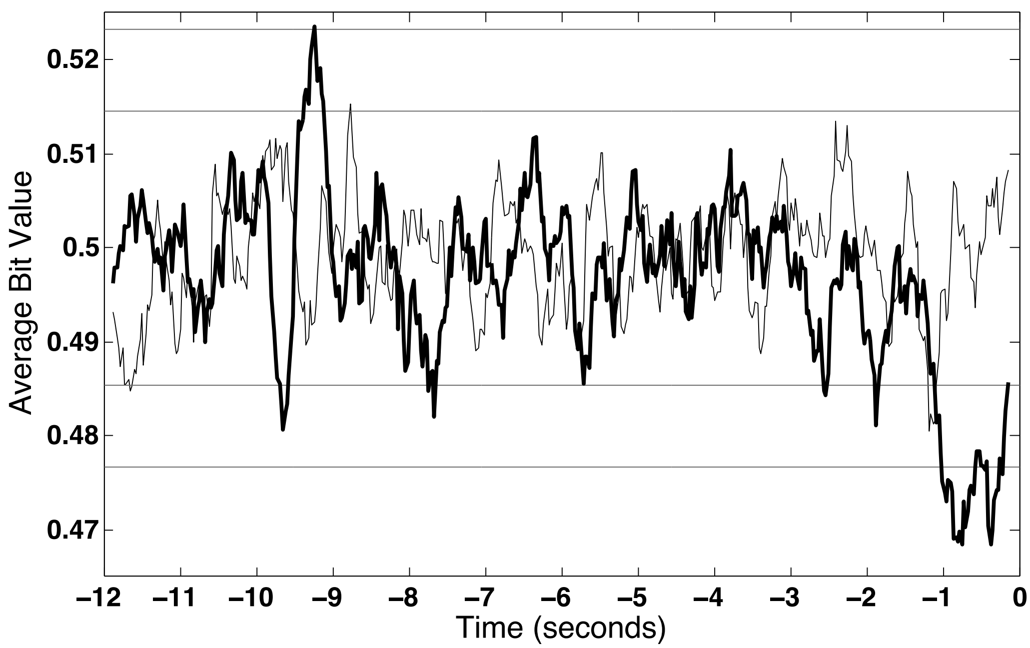

FIGURE 4. Run #3 average bit value produced by the subject-REG as a function of time before shut-off, carried out one day after Run #2. Both the test (thick line) and control (thin line) runs consisted of 578 trails. Other information is the same as that given in the caption of Figure 2.

We combined the data of Runs #1 - #3 into a single larger set of data, plotted in Figure 5. The features are the same, and the significance of the final dip in the test runs extends beyond the 99.9999% confidence level, with an average z-score of –6.5 in the last one half second.

As additional verification we replaced the controller-REG with a pseudo-REG. The pseudo-REG consisted of the "Random();" function in the C# program, which generates pseudo-random bits seeded by the computer clock. For each bit the program called for a new pseudo-random number. Besides the use of a pseudo-REG in place of the controller-REG the procedure was the same as for Runs #1 - #3. The results are shown in Figure 6. Although the final dip is more spiked in shape than from those in Runs #1 - #3, once again the dip extends beyond the 99.99% confidence interval.

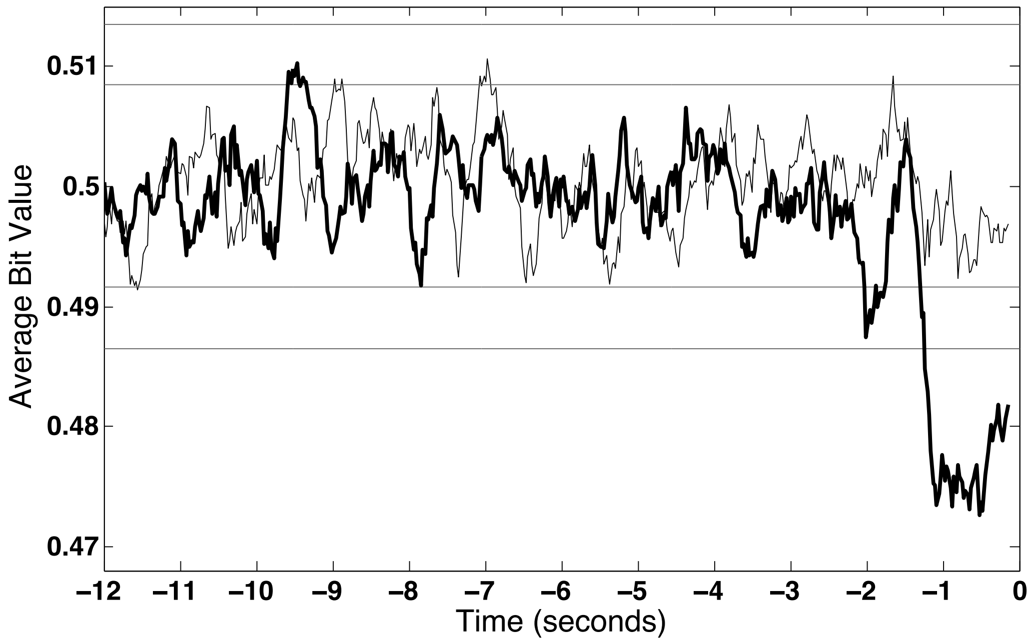

FIGURE 5. Combined data from Runs #1 - #3, showing the average bit value produced by the subject-REG as a function of time before shut-off. The test (thick line) and control (thin line) runs consisted of 1730 trails each. The average is for an 11-bit window, centered at the nominal time, and scanned across the time period before shut off. The REG produced 40 bits/sec. The closer-in horizontal lines correspond to 99% confidence intervals (two-tailed) and the lowest horizontal line corresponds to the 99.9999% confidence interval (two-tailed).

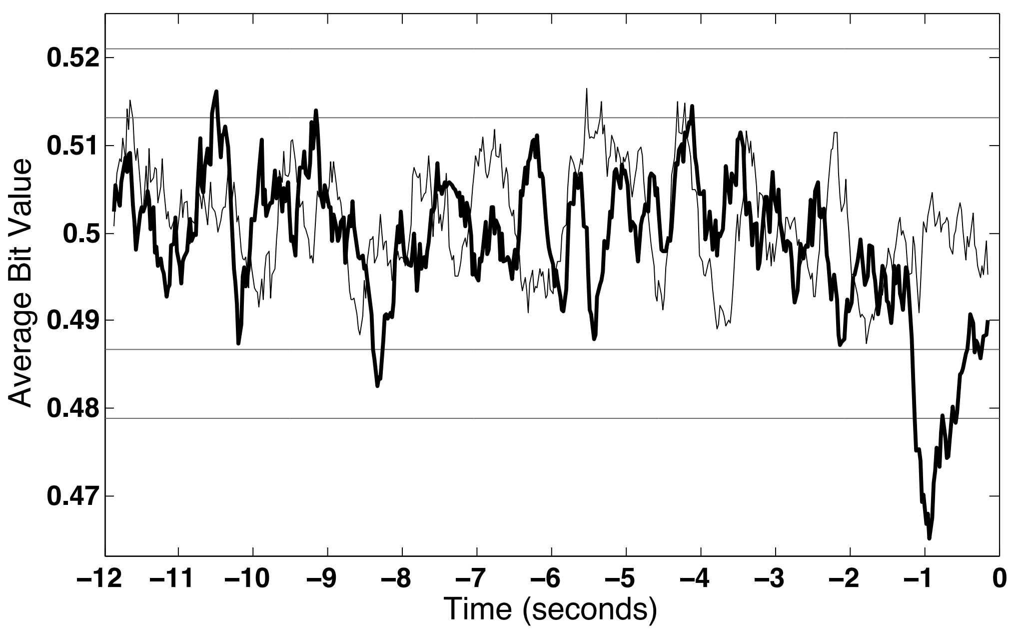

FIGURE 6. Pseduo-REG run, in which the controller-REG was replaced by a pseudo-REG using the "Random();" function in C#, carried out six days after Run #3. The average bit value produced by the subject-REG is shown as a function of time before shut-off. Both the test (thick line) and control (thin line) runs consisted of 705 trails. Other information is the same as that given in the caption of Figure 2.

There is evidence that a lower bit rates give larger responses in psychokinesis experiments [17]. An additional reason to explore lower bit rates is to see if the range of the roughly one-second time span of advanced response of the subject-REG is affected by the bit rate. Therefore we carried out a run with a bit rate of 10 bits per second, one fourth of the rate for the previous runs. The results are shown in Figure 7. In contrast to the Runs #1 - #3, there is no evidence of the dip before shut off.

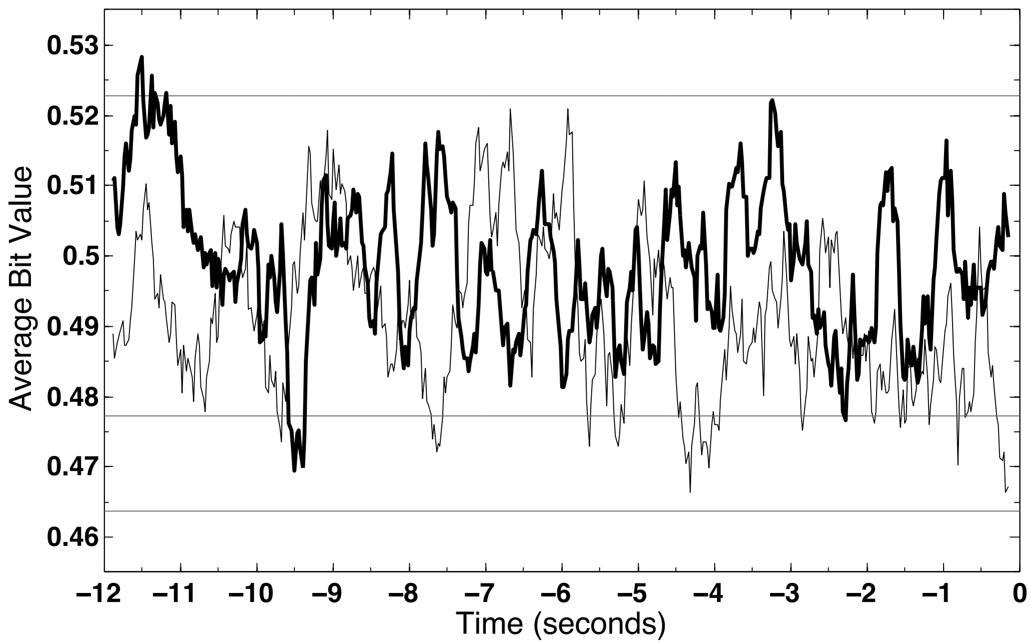

FIGURE 7. Lower bit-rate run, at 10 bits per second. The average bit value produced by the subject-REG is plotted as a function of time before shut-off.. Both the test (thick line) and control (thin line) runs consisted of 238 trails. Other information is the same as that given in the caption of Figure 2.

We then carried out a run with a higher bit rate, 100 bits per second. The results are shown in Figure 8. Again, there is no evidence of the sort of dip before shut off observed in the first three runs.

Twenty days after the initial successful run was carried out, we carried out a replication run, using exactly the same physical system and software. The results are shown in Figure 9. The results do not show the significant change in output before shut off that we observed in Runs #1 - #3. The initial effect disappeared upon replication.

DISCUSSION

The advanced response of the subject-REG in the last second before shut off observed in Runs #1 - #3 is statistically very significant. These results cannot be a fluke. We carried out multiple checks of the time stamps produced with each data point to make sure that the results were not due to some sort of misrepresentation of post-turn-off data as pre-turn-off data. There was no evidence of this. A second person

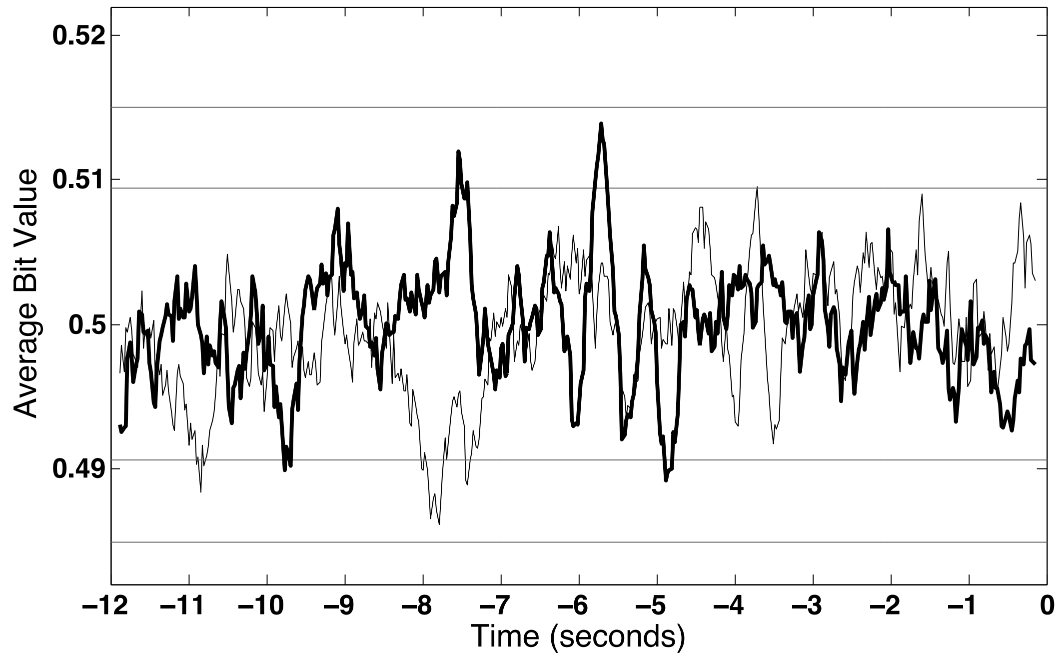

FIGURE 8. Higher bit-rate run, at 100 bits per second. The average bit value produced by the subject-REG is plotted as a function of time before shut-off.. Both the test (thick line) and control (thin line) runs consisted of 1388 trails. Other information is the same as that given in the caption of Figure 2.

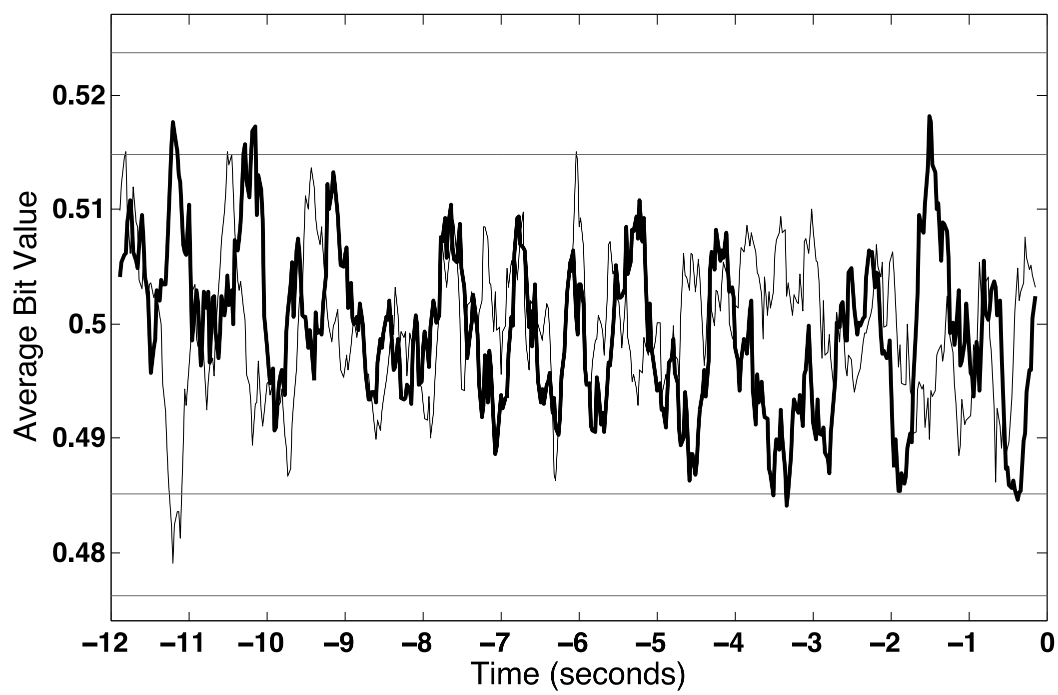

FIGURE 9. Replication of Runs #1 - #3, showing the average bit value produced by the subject-REG as a function of time before shut-off. The test (thick line) and control (thin line) runs consisted of 560 trails each. Other information is the same as that given in the caption of Figure 2.

using different software independently re-analyzed the data and found the same results. We found no evidence of electromagnetic interaction between the controller-REG and the subject-REG or any sort of measurable electromagnetic pick-up effect on the REG outputs. Even if there had been an interaction between the REGs, it could not have accounted for the subject-REG anticipating a shut off controlled by the controller-REG even before the controller-REG had produced the code require to initiate the shut off. There remained a remote possibility that some sort of external interference, possibly through the power lines or ambient electromagnetic fields, affected both the controller-REG and subject-REG to somehow produce the results that were observed. Such an interference could not have produced the results of Figure 6, which made use of a pseudo-REG in place of the controller-REG. The final piece of evidence that the results were not due to hardware or software artifacts can be seen from the replication carried out in the replication shown in Figure 9. The hardware, software and protocol were identical to those in Runs #1 - #3, and yet there was no significant dip in the output of the subject-REG in the final second before shut off.

The change appears to be an example of the infamous decline effect that plagues many psi experiments, along with other scientific investigations [18]. A caveat is that our results underwent a dramatic drop from a huge effect to none, as opposed to the usual gradual decline. A significant change in the conditions between Runs #1 - #3 and the replication were the attitudes, expectations and level of enthusiasm of the human operator (Zhu) and the experimenter (Moddel). Perhaps this was a cause for the decline. Thus, despite the attempt to set up an experiment to produce results that were independent of human interaction, it appears that our results may well be directly dependent on just that. In this light, the results are consistent with a long history of intention-based REG studies [19] [20] [21] with one significant exception: in our experiment one REG's output anticipated the output of a second REG before there was any human consciousness of that second REG output. In an earlier study, Yatskar investigated the predictions based on the numerical results of a computer calculation about a subsequent event, and found a significant number of correct predictions [22]. In that study, no comments were made as to whether the results might be an effect of operator consciousness. There are other uncontrolled parameters, such a variations in geomagnetic field and in local sidereal time. It is possible that such changes produce the decline we observed, but the dramatic step-change in those results from a strong effect to no effect do not appear to be consistent with subtle changes in these other parameters.

The effect size, defined in the Appendix, for the observed results in Runs #1 - #3 is approximately 0.05. This is much larger than the effect size of 10^{-4} observed in the PEAR program [21] and elsewhere [20]. This corresponds to approximately one bit in 40 being changed during the final second before shut off. It has been suggested that effect sizes are associated with time and effort [17]. That might be the reason for the large effect sizes we observed. In our case, the experimenter (Moddel) spent much time and energy in designing and arranging for this experiment, and once it was running thought about it constantly. For the operator (Zhu), this was his first psi experiment and he spent long hours tweaking the software and operating the system. In combination, much expenditure of time and effort, along with considerable enthusiasm, were associated with the initial runs.

It appears that the output of the subject-REG for Runs #1 - #3 genuinely changed just before the subject-REG was shut off, but there is another possibility. The alternative explanation is that output of the REGs and even the recording of that output in the computer memory remain as a superposition of states until the operator compiled and observed the data. Such a situation is analogous to, or possibly a direct example of, consciousness collapsing a quantum mechanical wave packet. This would be a real-life example of Schrödinger's cat. It is well known that von Neumann concluded that the wavefunction collapse must be caused by the consciousness of the experimenter [23]. This "checker effect" was observed in 1968 in experiments in which the person who checked the results of a precognition experiment affected the outcome [24]. Schmidt demonstrated this concept in a psi experiment, where he found that the statistical distribution of recorded clicks could be influenced by human intention after the recording took place [25]. Bierman investigated the process explicitly, and showed in a set of psi experiments that there is evidence for such a consciousness-induced collapse [26]. The data become fixed once they had been observed by a conscious entity.

If the subject-REG's output remains in a superposition of states until it is checked by a conscious entity, the question arises as to whether the retroactive influence was in response to the shut off, approximately one second later, or instead to the observation of the results, several hours later. In other words, did all the significant activity take place at the time when a plot like that shown in Figure 2 was formed? If so, no practical application of the subject-REG's ostensible retroactive influence could occur, because there was none. On the other hand, there are many published example of precognitive effects with human subjects who are retroactively influenced by sounds and images, as described in the Introduction. One might argue that these subtle precognitions did not reach the level of consciousness, and therefore may have remained in a state of indeterminacy until the measurements were tabulated and observed. There are many other cases of documented premonitions that people did act upon, and so the premonitions did not remain as a superposition of states until after the predicted event occurred [27]. Therefore, in at least some cases a genuine retroactive influence occurs. If the results found in this experiment are due to a superposition of states that collapse into one only when checked, then that too is a form of retroactive influence, but an influence of the observation (checking) rather than the shut off event.

Whether the retroactive influence on the subject-REG was in response to its impending shut off or to the checking, there appears to be an overwhelming experimenter effect on the data, since the results of Runs #1 - #3 are so different from the replication run. Experimenter effects are notorious in psi research, and are often cited at the cause for inconsistencies in observed effects [28]. In our case the effect is very large, shifting results that showed odds against chance of well over 1 million to one down to results that are very close to chance. Such a large effect brings into question nearly every short-term psi study that attempts to measure the effect of a particular variable on a psi phenomenon. Clearly the psi phenomena exist, but whether the particular variable has any effect or whether the effect is due solely to the expectation of the experimenter is an open question.

CONCLUSIONS

The output from a random-event generator (REG) has been shown to deviate from randomness in advance of its being shut off. The deviation is so large in statistical terms – odds against chance of greater than 1 million to one – and relatively large in absolute terms – approximately 1 bit in 40 – that the effect cannot be dismissed as a statistical fluke. Multiple checks of every part of the system were carried out, and the data were analyzed independently by two people using different software to make sure the results were not an artifact of hardware or software errors. The result was observed in the three initial sets of trials.

Despite the robustness of the result, an exact replication of the experiment carried out 20 days later failed to show the same deviation from chance in the REG output before shut off. An uncontrolled parameter, possibly the intention and enthusiasm of the human operator and experimenter, was the dominant factor in determining the result. The initial runs involved the investment of much enthusiasm and time, whereas the emotional component associated with the replication was less vibrant.

The results were observed in the form of curves of output versus time displayed on a computer screen after each set of trials was completed. It is not known whether the REG actually registered its impending shut off, or whether its output and the data stored on the host computer remained in a superposition of different states, like Schrödinger's cat, until the result was observed by the human operator.

ACKNOWLEDGEMENTS

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APPENDIX

Statistical Analysis

For each trial the standard deviation for a window of *n* binomial, equal probability, bits is equal to $\sigma_t = 0.5\sqrt{n}$. For that window applied one run consisting of *N* trials, the expected standard deviation is

$$\sigma = \frac{\sigma_t}{\sqrt{N}} . \tag{1}$$

For a window in each trial the expected average was $\mu = n/2$. The sample mean across *N* trials for each window was

$$Y = \frac{\sum Y_t}{N} . \tag{2}$$

The resulting z-score is

$$z = \frac{Y - \mu}{\sigma}. \tag{3}$$

The two-tailed confidence intervals of 95%, 99.9%, 99.9999 correspond to z-scores of 1.960, 3.291, and 4.892, respectively.

Effect size is defined as

$$e = \frac{z}{\sqrt{N}} = \frac{h - p}{\sqrt{p(1-p)}} \tag{4}$$

where h is the actual hit rate and p is the mean-chance expectation. For a binary equal-probability system

$$e = \frac{h - p}{\sqrt{p(1-p)}} = 2(h - 0.5). \tag{5}$$

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