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Experiments Investigating the Influence of Intention on Random and Pseudorandom Events*

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Abstract—Eight of 27 experiments using a random event generator provided statistical evidence supporting a claimed correlation between intention and the distribution of random events. Twelve control tests produced results conforming closely to chance expectation.

Introduction

Over the last three decades, some 68 researchers have reported more than 800 experiments investigating the possibility that people may have an ability to influence simple random systems solely through the application of mental intention (Radin & Nelson, 1987; Radin & Nelson, in press). Overall, the results of these experiments provide evidence for the existence of a correlation between intention and the statistical behavior of electronic random event generators (REG). The claimed effects are relatively weak in absolute magnitude, and are evidenced by small shifts of various distribution parameters from chance expectation (usually the mean or the variance). In such experiments, participants attempt to influence sequences of random or pseudorandom events produced by electronic REGs by assigned or operationally defined mental intention. REGs are based upon truly random events such as radioactive decay or electronic noise, or use pseudorandom algorithms seeded with truly random numbers.

One of the first investigations of the possible influence of intention on radioactive decay rates was reported by Beloff and Evans (1961). They asked people to alternatively increase or decrease the count rate of a Geiger

* This paper is a revised version of a technical report presented by the first author at a conference in 1981 (Radin, 1982). Prompted by Schmidt's (1987) reference to that report in this Journal, we decided to reanalyze and publish the data reported in the Radin (1982) paper, including several. previously unpublished experiments performed with the same random event generator.

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counter subjected to a source of alpha particles. The study was not statistically successful. Participants in several other studies in the 1960's had varying degrees of success in attempting to influence alpha, beta, and gamma particles (e.g., Chauvin & Genthon, 1965).

In the late 1960's, Helmut Schmidt developed a random event generator (REG) based upon the random waiting times between successive emission of beta particles from strontium 90 (e.g., Schmidt, 1970, 1971). Schmidt's REG generated random events by stopping a fast (one megahertz) binary counter when a Geiger tube detected a beta particle. Since radioactive sources theoretically emit particles at random time intervals, the probability that a binary switch would stop at a "1" would be the same as a "0."

The present paper reports a series of experiments conducted using an REG designed and constructed by Schmidt, and kindly loaned to the first author. In the studies described below, the random element in the REG was based upon the waiting times between successive emissions of gamma particles from radioactive ore (pitchblende). Volunteers were asked to concentrate on audio and/or visual feedback in a task that, if successful, would affect the statistical properties of the random events.

Method

Random Event Generator

The test machine is illustrated in Figures 1 and 2. The functions of the machine are controlled by a microprocessor (INTEL 8035) and several external switches and controls. Data reported in the studies below were automatically collected by the microprocessor and stored in a memory chip (INTEL 2716 PROM).[1] The automatic data recording method enabled the experimenter to double-check and allow independent verification of the data.

To prevent a participant from erasing the results of a poor run by turning the machine's power off during such a run, the microprocessor was programmed to increment the data storage counter at the beginning of each run, and record this number in the PROM. Thus, if the power was turned off, the data chip would record a zero score in that memory slot. Later, when the experimenter read the run scores off the data chip, the empty memory slots would be immediately apparent.[2]

The face of the machine shows 16 lamps arranged in a circle (Figure 1). When the microprocessor is reset, and the "PUSH" button is pressed, a program on a PROM chip starts running in the "direct" mode or "seed" mode, depending on how an external switch has been set.

Direct Mode. In the "direct" mode of generating random events, lamps starting at the top of the circle are sequentially illuminated in the clockwise (CW) direction at a rate of 4 Hz such that one light is lit at any one time. With each jump, a "hit" counter records the total number of CW steps.

When a Geiger tube detects a gamma particle, it sends a signal to the

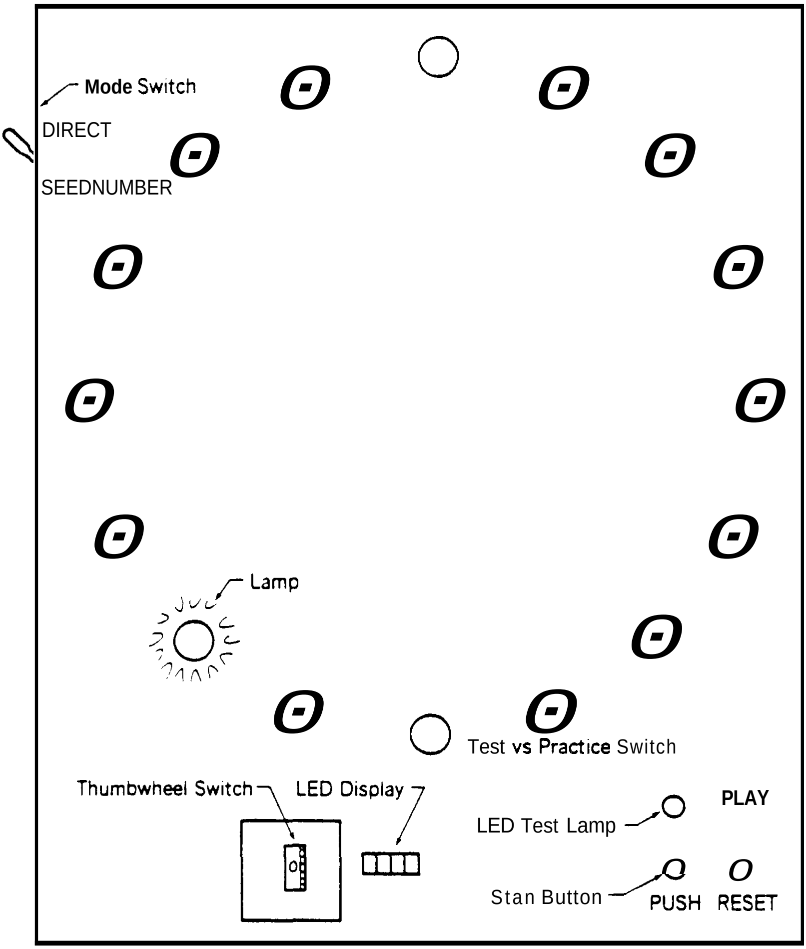

Fig. 1. Front view of random event generator

microprocessor, which stops the CW pattern of the lights and begins a counter-clockwise (CCW) sequence. A "miss" counter records the number of CCW steps. When another gamma particle is detected, the lights start moving CW again, and so on.

This alternating CW-CCW illumination sequence is repeated until a pre-specified number (e.g., 16, 32, 64) of CW-CCW pairs have been completed. A thumbwheel switch on the face of the machine is used to specify the number of pairs. At the end of one run of say. 16 pairs, an LED display shows the total number of CW and CCW steps and the data is stored in the memory chip.

Seed Mode. In this mode, a 19-bit seed is generated by stopping a one megahertz counter when the Geiger tube detects a gamma particle. The

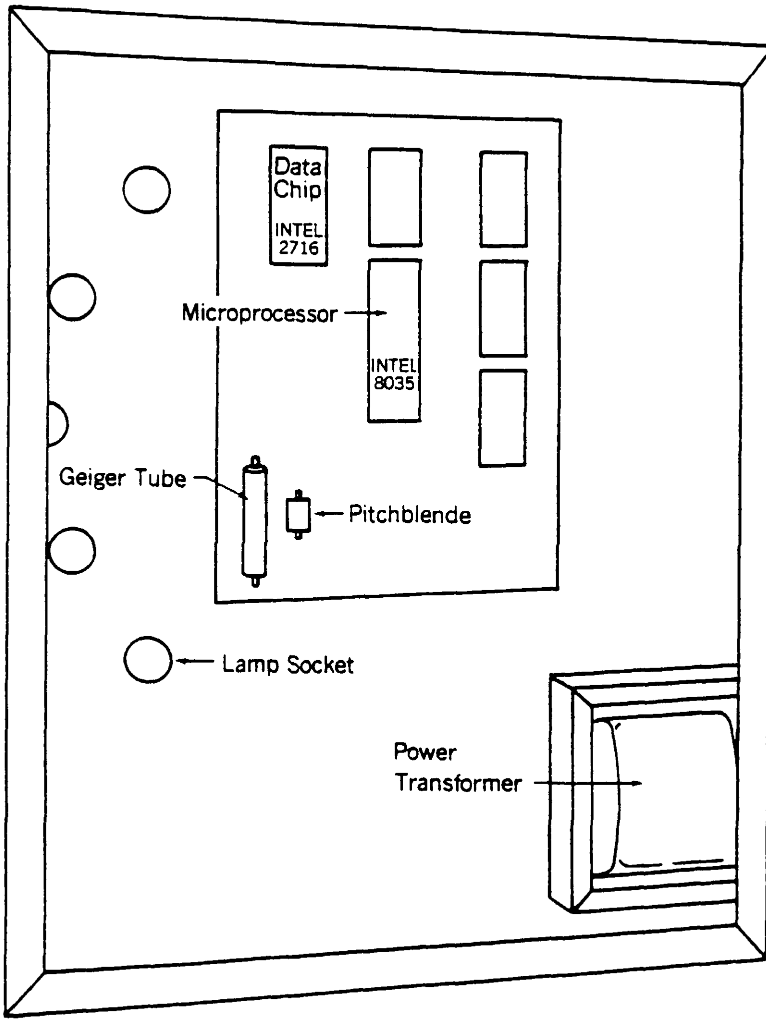

Fig. 2. Inside view of random event generator, viewed from the back.

microprocessor uses this 19-bit seed to initiate a sequence of 19-bit pseudorandom numbers such that the sequence contains every possible 19-bit number. This particular algorithm generates over a half million different numbers before repeating.[3] The four least significant bits of each pseudorandom number are used to determine one number in the range 1 to 16. During test runs, numbers are generated at a typical rate of 8 per second. With each generated random number (RN), a light jumps CW until RN = 3 has been obtained. Then the lights move CCW until a RN = 12 has been generated. This process continues until 16 CW-CCW pairs have been completed.

As in the direct method, the experimental participant tries to make the lights move CW more than CCW, thus extending the time periods of CW illumination and shortening the periods of CCW illumination.

Note that both methods have a built-in control feature—reversing the lamp illumination direction on successive "hits" (i.e., gamma particle in the direct mode and a specified pseudorandom number in the seed mode). For this control to be defeated, a long-waiting-time followed by short-waiting-time periodicity must be systematically present throughout all runs. Any such periodicities should become immediately apparent upon running control tests in which the REG is set up to run without human intervention. Studies 1, 3, 4, 5, 6, and 8 (described below) employed such control tests.

Feedback

In addition to the flashing lights, audio feedback was provided by a tone generator. Whenever the lights started moving CW, the tone generator produced a gong-like tone. This tone persisted until the lights started moving CCW, then no tone was generated. Audio feedback was provided through headphones connected to the test machine.

In all of the experiments reported here, rather than show CW-CCW motions, an optional feedback mode was employed, which was to show CW motion as usual, but no motion instead of CCW motion. This feedback was chosen because in pilot tests it was found to be less distracting than the constant motion provided in the CW-CCW feedback.

The subject's task, then, was to try to maintain the CW "hit" state for as long as possible and the stopped "miss" state for as short a time as possible. The visual task was to keep the lights moving, and the audio task, to keep the sound going.

Comparison of Direct and Seed Modes

In one respect, the seed mode is superior to the direct mode in generating random events because it relies upon a mathematical algorithm rather than a naturally occurring random event. Compared to a Geiger tube, for example, an algorithm is relatively insensitive to extraneous radiation and electrical disturbances. However, the deterministic nature of pseudorandom number generation makes interpretation of successful experiments somewhat more complex. Because an algorithm completely determines the results of a run once the starting seed has been selected, it would seem that any mental effort applied during a seed mode run would have to be focused "backwards" in time in order to influence the selection of a favorable seed. Although the existence of such a backwards effect defies common sense, mathematical models have been proposed that support such a focusing concept and predict the effect to operate backwards in time as efficiently as in present time (Schmidt, 1975, 1976, 1978).

Another way of interpreting positive results observed in the seed mode is to postulate that precognition is the mediating factor. Precognition[4] would be used to select favorable, future moments in which to start a seed mode run. Under this interpretation, if a person could "see" the result of a future run before actually starting it, he or she would simply wait for a propitious time that would result in selection of a particular seed, which would in turn produce the desired result (e.g., more hits than misses). An analysis of existing RNG experiments provides some support for the precognition interpretation (May, Radin, Hubbard, Humphrey, & Utts, 1986).

A third interpretation is that positive effects are due to subtle strategies developed by the subjects, consciously or unconsciously, that somehow take advantage of inherent periodicities in pseudorandom number sequences. Such strategies, even if they were possible to develop and apply systematically, could not be used with the present REG because the selection of the seed number is based upon a truly random event, i.e., radioactive decay. And as we have mentioned above, once the seed is selected, the rest of the random generation process is completely determined. Thus, no normal strategy could be employed to influence results produced in the seed mode.

Hypothesis and Statistical Methods

The hypothesis for each experiment was simple: If intention can affect the distribution of random events, then the total number of CW steps, defined as hits in many of these experiments. would be greater than the total number of CCW steps. This hypothesis was tested with the formula[5]

$$Z = \frac{(H - M)\sqrt{2N}}{\sqrt{(H + M - 2N)(H + M)}},$$

where H = total number of CW counts, M = total number of CCW counts, N = total number of samples in the CW direction,[6] and Z is a standard normal deviate. Because a directional hypothesis was postulated, probabilities are reported one-tailed.

Results

Table 1 summarizes results of all experiments conducted by the first author using the same REG. They range from Study 1, conducted in November, 1980, to Study 12, conducted in December, 1983. Short descriptions of each test follow:

Study 1

The first experiment consisted of the first author (DR) as subject, running the REG for a preset total of 60 direct mode runs of 16 CW-CCW pairs per run, in three daily sessions of 20 runs each. This test was performed in the evenings, in a secure location, in a relaxed setting, and with no distractions. After each run the number of hits and misses was manually recorded.[7]

TABLE 1
Results of experimental and control tests

	Subject	Mode	Condition	Hits	Misses	Runs[a]	Z
Study 1	DR[b]	direct	E[c]	14896	13644	60	1.990†
	DR	direct	C	13135	13729	60	−1.005
Study 2	CY	direct	E	3820	3385	15	1.369
	JK	direct	E	3671	3769	15	−0.298
	MD	direct	E	3994	3398	15	1.827*
	RW	direct	E	3865	3538	15	1.001
	TD	direct	E	3471	3691	15	−0.697
	WL	direct	E	3466	3519	15	−0.172
	AK	direct	E	3623	3236	15	1.282
	HF	direct	E	3474	3446	15	0.092
	RK	direct	E	3550	3545	15	0.016
	SR	direct	E	3835	3546	15	0.887
Study 3	AK	direct	E	3413	3840	15	−1.335
	AK	direct	C	4057	3527	15	1.582
	CY	direct	E	3974	3230	15	2.342†
	CY	direct	C	3743	3652	15	0.279
	MD	direct	E	3563	3756	15	−0.598
	MD	direct	C	3559	4045	15	−1.447
	RW	direct	E	3093	3494	15	−1.385
	RW	direct	C	3685	3950	15	−0.786
	SR	direct	E	3688	3168	15	1.723*
	SR	direct	C	3727	4046	15	−0.928
Study 4	DR	direct	E	11963	10936	50	1.860*
	DR	direct	C	11926	11540	50	0.682
Study 5	DR	seed	E	12236	12780	50	−0.899
	DR	seed	C	12600	12176	50	0.708
Study 6	DR	seed	E	13251	12086	50	1.900*
	DR	seed	C	12223	12696	50	−0.785
Study 7	DR	seed	E	13361	12235	50	1.817*
	DR	seed	C	12611	12985	50	−0.604
Study 8	DR	seed	E	11844	13062	50	−2.022†
	DR	seed	C	12169	12737	50	−0.943
Study 9	DR	seed	E	26835	25018	100	2.046†
	DR	seed	C	25822	26031	100	−0.235
Study 10	RS	direct	E	2445	2197	10	0.990
	RS	seed	E	2319	2251	10	0.276
Study 11	BJ	seed	E	33520	33676	128	−0.153
	BJ	direct	E	30557	29539	128	1.123
Study 12	BN	direct	*E*	13326	13159	64	0.297

* Significant at $p < .05$, one-tailed.
† Significant at $p < .05$, two-tailed.
[a] There were 16 clockwise (and counter-clockwise) samples per run.
[b] DR is the first author. Excepting BN, all other subjects were unselected volunteers claiming no special abilities.
[c] E = experimental, C = control condition.

After completing the 60 test runs, a series of 60 control runs was performed in which the lights were covered and the headphones unplugged. The machine was located in the same place and under the same conditions as in the experimental condition. During control runs DR engaged in other tasks. pausing every so often to begin the next run. When each control run had completed, the number of hits and misses was manually recorded.

Study 2

In this experiment, DR recruited 10 volunteers from AT&T Bell Laboratories, Columbus, Ohio. Each participant performed 15 runs in the direct mode for a total of 150 runs pooled across subjects. The experimental runs took place in the Human Factors Laboratory at the Columbus Labs. Each subject was instructed in the use of the machine, and each was allowed to perform as many practice runs as he or she wished before beginning the formal data collection. Because Study 1 showed no systematic (first-order) bias in the control condition, no separate control condition was included in this study.

Study 3

This experiment consisted of rerunning the top five scorers from Study 2, where top scorers were defined as those persons obtaining the top five greatest excesses of hits over misses. This process was intended to select the more "talented" subjects from Study 2, even though it was recognized that those subjects could have obtained their higher scores by chance. Each individual performed 15 direct mode runs in the Human Factors Laboratory, for a total of 75 pooled runs. Immediately after each subject's 15-run session, DR ran a 15-run control session. During the control runs the face of the test machine was covered and the headphones unplugged, as in the first control study, so no feedback could be heard or seen.

Study 4

This test was an attempt to replicate the results of the first experiment. The experiment was performed by DR in the direct mode, in the same relaxed, undisturbed setting as in Study 1. This time, however, 5 sessions of 10 runs each were performed over 5 successive days, for a total of 50 runs in experimental and control conditions.

Study 5

In this study, DR ran the REG in the seed mode. The setting was quiet and undisturbed, and one or two sessions of 10 runs each were performed per day until 50 test runs were completed. Immediately after completing the 50 test runs, 50 control runs were performed. The test procedure was to reset the microprocessor, wait for a seed to be generated (this random waiting time was usually between 1 and 5 seconds), then try to influence the REG to produce more clockwise motion than no motion. The control procedure was identical except that no directional intention was applied, the face of the test machine was covered, and the headphones unplugged.

Study 6

In this study, DR tested a possible time-displaced effect. Conditions of the test were the same as in Study 5, except that several seconds after the REG generated the seed for a run, a task was randomly selected by stopping a digital stopwatch and examining the hundreds-place digit. If the digit was even, the task was to try for as much clockwise motion as possible. If the digit was odd, the task was to try for as much "no motion" as possible. That is, what counted as success on each run was randomly selected between clockwise motion and no motion (recall that a feedback option allowed CCW motion to be reset into no motion).

It is important to realize that at the moment the seed was generated, DR did not know what would constitute success (i.e., CW motion or no motion). Thus, the momentary generation of the seed could not be "influenced" as might be the case in other studies reporting time-displaced effects (e.g., Schmidt, 1975, 1976). The distribution of randomly assigned tasks in the experimental and control conditions showed 27/50 even tasks (i.e., try for CW motion tasks) in the experimental condition and 23/50 even tasks in the control condition.

Study 7

This study was a replication of the previous study, except that the control condition was performed by generating 50 new tasks. In the experimental condition, 22/50 tasks were even (i.e., try for CW motion), and in the control condition, 24/50 were even.

Study 8

A few REG experiments have provided evidence that subjects may be able to influence REG statistics even when they are unaware of the task (e.g., Stanford, Zenhausern, Taylor, & Dwyer, 1975). This study investigated whether the effect observed in the previous two studies could be achieved when the task was unknown. The experimental procedure was similar to that in Studies 6 and 7, except that instead of looking at the random task before the feedback, DR looked at it after the feedback. In this way, tasks remained hidden during the test runs.

Study 9

Because Studies 6 and 7 were successful (see Table 1), but Study 8 was not (at least, not in the directional sense), an experiment was planned as a replication of Studies 6 and 7. Preset at 100 runs, the experimental procedure was the same as in Studies 6 and 7, but the following method was used as a control: The sum of all CW counts was taken as the control score for hits, and the sum of all CCW counts was taken as the control for misses. Recall that the definition of "hits" and "misses" in this study, and in Studies 6 and 7, depended on the assigned directional *task* for each run. These tasks (aim for CW or CCW counts) were generated *after* the seed numbers were selected, but before the feedback was presented. Thus, experimental hits and misses consisted of combinations of CW and CCW counts, depending on the task for each successive run.

It is important to note that the directional tasks generated from one run to the next (by the method described in Study 6, above) were recorded manually. While it is unlikely that systematic recording biases could have influenced the data given that the task was generated *before* the results of a run were known, manual recordings are less certain than automatic recordings, and thus results of Studies 6–9 should be considered as tentative only.

Study 10

Subject RS, a surgeon highly skeptical of psi phenomena, contributed 10 runs in both direct and seed modes, in the first author's presence.

Study 11

Subject BJ, a homemaker, claimed no special abilities but was interested in participating in the experiment. She was allowed to keep the REG for one month at home, and was instructed to perform 128 runs in both the seed and direct modes. Upon reading out the scores on the PROM chip, no instances of data selection or turning off the REG's power during a run were detected.

Study 12

Subject BN, a homemaker, claimed a variety of psychic abilities. She was allowed to keep the REG for one month, at her home, and was instructed to perform 64 runs in the direct mode. No attempts at data selection were detected upon reading out the scores on the PROM chip.

Discussion

Figure 3 shows the same information as Table 1, but in the form of cumulative deviation curves for experimental and control studies. Figure 4 shows these curves separated by direct or seed mode of operation.

Figure 3 reveals that the experimental condition produced a significant deviation from chance (terminal $Z = 2.941$, $p = .002$) and that the control condition remained within the chance expectation envelope (terminal Z

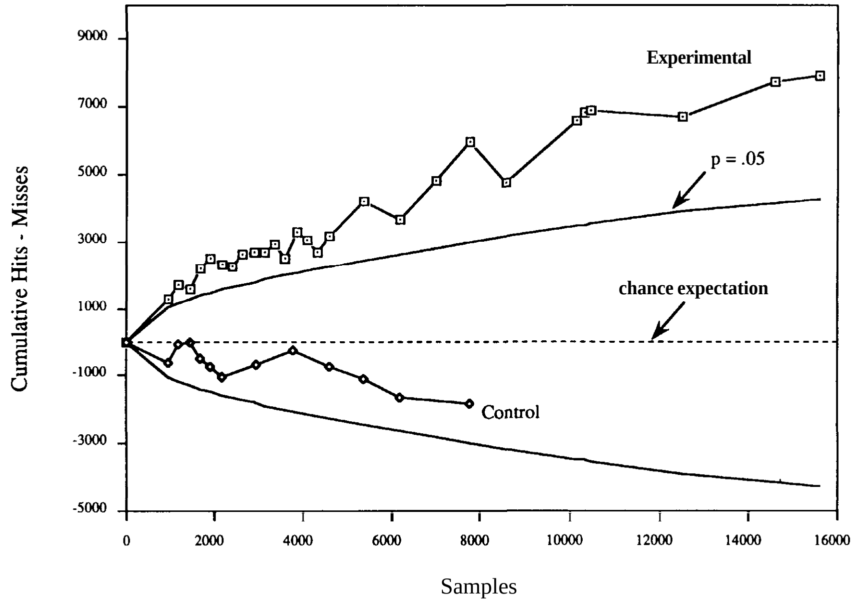

Fig. 3. Cumulative deviation of hits–misses from chance expectation (as defined by the assigned directional task) for all experimental and control tests. The parabola shows the p = .05 level.

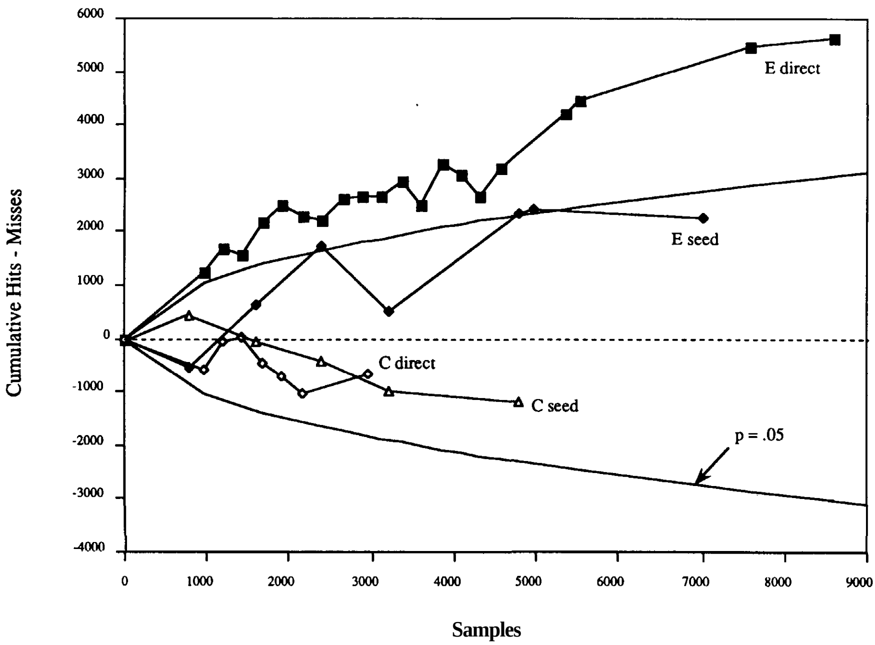

Fig. 4. Cumulative deviation of hits–misses from chance expectation, separated according to experimental condition and mode. "E" indicates the experimental condition and "C" the control condition. The parabola shows the p = .05 level.

$= -1.005$, $p = .843$). Figure 4 indicates that the primary significance was obtained in the direct mode (terminal $Z = 2.754$), but the seed mode also contributed to the positive trend (terminal $Z = 1.121$).

In Table 1 we see that 8 of 27 experiments and 0 of 12 control tests were significant at $p < .05$, one-tailed. This corresponds to $p = 3.67 \times 10^{-5}$, one-tailed, and $p = .540$, respectively.[8] Because the first author, DR, was subject in 7 of the 12 Studies, it is instructive to examine the results when other individuals participated as subjects. From Table 1 it can be seen that 3 of 20 experimental tests not involving DR as subject produced results with $p \leq .05$ ($p = .076$), 5 of 20 tests resulted in $p \leq .10$ ($p = .043$), 7 of 20 resulted in $p \leq .15$ ($p = .022$), and 9 of 20 resulted in $p \leq .20$ ($p = .0099$). This suggests that the overall level of significance is not only due to DR's contributions.

Conclusion

Eight of 27 experiments using a random event generator constructed by Helmut Schmidt, and independently tested by the first author, confirmed a claimed correlation between intention and the statistical distribution of random events. Twelve control tests were non-significant.

In isolation, the anomaly observed in this experiment would be interesting, but not particularly persuasive. This is because there are, at present, no compelling theoretical reasons to predict the existence of such an effect. However, in spite of prevailing theory, three independent reviews of experiments using REGs have agreed that the aggregate evidence for this effect is exceptionally persuasive (Honorton, 1978; May, Humphrey, & Hubbard, 1980; Radin & Nelson, 1987; Radin & Nelson, in press). The anomaly has resisted repeated efforts to "explain-away" the evidence as being due solely to methodological artifact, statistical problems, or experimenter or subject fraud.

Numerous theorists have proposed mathematical, physical, and psychological models to explain how such effects might be possible (e.g., Bastin, 1977; Costa de Beauregard, 1979; Jahn & Dunne, 1986; Schmidt, 1975; Walker, 1974). These models attempt to provide world views which encompass concepts such as acausality and time-displacement. Some of these efforts have been inspired by interpretations of quantum mechanics which suggest that objects in the world may not be completely independent of consciousness or observation (e.g., d'Espagnat, 1979; Hall, Kim, McElroy, & Shimony, 1977; Mermin, 1985; Shimony, 1963; Squires, 1987, in press; Trefil, 1987; Wigner, 1963). Some theorists argue that rather than being paradoxical or contrary to theoretical expectation, some form of mental influence on physical objects should in fact be expected. We close with the intriguing thoughts of the physicist, Costa de Beauregard (1979, p. 186):

> My thesis is that [these phenomena] are postulated by the very symmetries of the mathematical formalism [of quantum theory] and should be predicted for reasons

completely akin to those that led Einstein to enunciate the principle of special relativity, de Broglie to produce the concept of matter waves, and Dirac to (almost) predict the positron.

Endnotes

[1] With one exception, as noted below.

No cases of attempted data selection were detected in these experiments.

[3] The algorithm is $r(n+1) = [B \times r(n)][\bmod p]$, where $p = 2^{19} - 1$ and $B = 243^6$. See Hardy and Wright (1945) or Radin (1985) for further details on generation of pseudorandom number sequences.

▾ ▾ recognition is defined here as non-inferential prediction or perception of future events.

[5] See the Appendix for a derivation of this formula.

[6] There were 16 CW and 16 CCW samples per run, thus N = total number of runs*16.

[7] A hardware problem disabled the fully automatic recording mode in this study, thus the recorded numbers of hits and misses in Study 1 are not as dependable as those in succeeding experiments. All other studies were recorded both manually and automatically on the PROM. No discrepancies were detected when manual and automatic recordings were compared.

[8] Exact binomial probabilities.

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Appendix

We assume there is a fixed probability that the random process will cause the REG to reverse the lamps' direction while any specific lamp is "moving" in the clockwise (CW) or counter-clockwise (CCW) direction. If we call the CW probability P_H and the CCW probability P_M, then the null hypothesis of interest is $P_H = P_M$.

Let X, and Y_i be the number of lamps lit in the CW and CCW directions, respectively, for sample i, where i = 1, . . . , N. Then $P(X_i = 1) = P_H$, $P(X_i = 2) = (1 - P_H)P_H$, $P(X_i = 3) = (1 - P_H)^2 P_H$, and in general, $P(X_i = x) = (1$

$- P_H)^{x-1}P_H$. This is known as a geometric distribution with parameter P_H. Similarly, Y_i follows a geometric distribution with parameter P_M.

Let H = $\sum_{i=1}^{N} X_i$, and M = $\sum_{i=1}^{N} Y_i$, where N is the total number of samples in the experiment. (In the current experiment, one "run," initiated with a single button press, produced 16 CW and CCW samples.) Since H and M are each sums of independent geometric random variables, they have *negative binomial distributions* with parameters (N, P_H) and (N, P_M), respectively. Thus, $E(H) = N/P_H$ and $\mathrm{Var}(H) = N(1 - P_H)/P_H^2$. Similar results hold for M.

Instead of testing the null hypothesis, $H_0{:}P_H = P_M$, directly, we test the equivalent but intuitively more appealing hypothesis, $H_0{:}E(H) = E(M)$. Relying on the Central Limit Theorem, we use the standardized version of H – M as our test statistic.

When H_0 is true, E(H – M) = 0 and $\mathrm{Var}(H - M) = \mathrm{Var}(H) + \mathrm{Var}(M) = 2N[(1 - p)/p^2]$, where $p = P_H = P_M$. To estimate $\mathrm{Var}(H - M)$, substitute $\hat{p} = 2N/(H + M)$ for p. Thus, the test statistic, which should be compared to the standard normal table, is:

$$Z = \frac{(H - M)}{\sqrt{\dfrac{2N(H + M - 2N)(H + M)^2}{(H + M)(2N)^2}}} = \frac{(H - M)\sqrt{2N}}{\sqrt{(H + M - 2N)(H + M)}}.$$