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Exploring Relationships Between Random Physical Events and Mass Human Attention: Asking for Whom the Bell Tolls

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Abstract—Exploratory study of the outputs of continuously operating truly random number generators (RNG) located around the world indicated that the largest daily change in variance in the year 2001 occurred on an unprecedented day in United States history, September 11, 2001. Calculation of correlations between all possible pairs of RNG outputs on a per-day basis showed that the largest daily average correlation also took place on September 11. Comparison of daily RNG correlations for 250 days that made headline news in 2001 according to a commercial news service vs. similar measures for 115 non-eventful days showed a larger average RNG correlation on days with major news events ($p = 0.011$). More generally, the correlation between an objective metric of daily news vs. the daily average RNG correlation was significantly positive ($p = 0.001$). Potential environmental artifacts were examined and found to be implausible explanations for these results. One interpretation of these findings is that mind-matter interaction effects previously observed only in focused laboratory studies may be detectable outside the laboratory, potentially at a global scale.

Keywords: randomness—attention—mind

Introduction

As I grew up I became increasingly interested in philosophy, of which [my family] profoundly disapproved. Every time the subject came up they repeated with unfailing regularity, "What is mind? No matter. What is matter? Never mind." After some fifty or sixty repetitions, this remark ceased to amuse me.

—Bertrand Russell

Generations of philosophers have vigorously debated the questions that taunted Bertrand Russell, so far without much resolution. In an experimental approach to this question, investigators have examined the outputs of electronic noise-based, truly random number generators (RNG) before, during and after highly focused or coherent group events. The group events studied included intense psychotherapy sessions, captivating theater presentations, religious rituals, popular sports competitions, like World Cup Soccer, and high-interest television broadcasts like the Academy Awards (Bierman, 1996; Blasband, 2000; Nelson, 1995, 1997; Nelson et al, 1996, 1998a, 1998b; Radin, 1997; Radin et al, 1996;

Rowe, 1998; Schwartz et al, 1997). Results of these studies suggest in general that mind and matter are entangled in some fundamental way, and in particular that focused mental attention in groups is associated with negentropic fluctuations in streams of truly random data.

Unlike laboratory investigations of mind-matter interactions involving RNGs, where typically one individual is asked to mentally *intend* the output of an RNG to deviate from chance, the present experiments study groups of coherent minds that are paying *attention* to external events and explore whether these moments are associated with analogous states of coherence in matter. RNGs are used as the "matter" in these experiments because methods for detecting statistical order in sequences of random events are well established, techniques for generating and recording truly random bits are well understood, and several hundred independently replicated, previously reported laboratory studies provide support for the hypothesis that under certain conditions, mental intention and random events can become significantly correlated (Radin & Nelson, 1989, in press).

In 1998, Roger Nelson initiated the Internet-based Global Consciousness Project (GCP) to significantly expand this line of research by providing numerous parallel, continuous streams of truly random bits from well-calibrated, noise-based RNGs located around the world (Nelson, 2001). In these studies, mass mental coherence is inferred to take place as a result of major news events which attract widespread attention, and it is around these times that negentropic changes are predicted to occur in the RNGs. This hypothesis has been formally tested in the GCP data by examining whether the cumulative deviation in variance across the random bit streams shifts from chance expectation, usually by examining RNG data from just before an event of widespread interest to a few hours afterward. As of May 2002, some 104 such events had been formally tested, with overall significant results ($p < 3 \times 10^{-7}$)[1]. With growing support for the GCP mind-matter interaction hypothesis, I was motivated to examine the data over longer time periods than had been previously studied, with special interest in exploring how RNG outputs behaved on days with major news events as compared to relatively uneventful days.

Devices and Data

A more detailed account of the hardware and software that comprises the GCP network can be found in Nelson (2001, 2002). The following brief description will suffice for the present analyses. The GCP RNGs are not software-generated pseudorandom numbers, but hardware circuits that rely on inherent electronic noise as a source of randomness. Of the three different types of RNGs employed in the GCP network, one uses noise in resistors and the other two use quantum tunneling in solid-state junctions. The RNGs are designed for professional applications requiring highly reliable generation of truly random bits, and each has passed standard tests for randomness (e.g., Marsaglia's DIEHARD test, no date) as well as calibration tests consisting of one million 200-bit trials.

All of the RNGs are solid-state circuits housed in electromagnetically shielded boxes, and the noise-based random bit sequences are compared to an equal number of 0 and 1 bits with a logical exclusive or (XOR) to ensure that the mean output is unbiased regardless of environmental conditions, component interaction, or aging.

Each RNG is attached to a personal computer which collects random bits into one "trial" per second, where each trial is the sum of 200 random bits. These trials theoretically follow a binomial distribution with mean = 100 and variance = 50. Each computer records its trials into time-stamped files, and all computer clocks are synchronized to standard Internet time servers. Packets of data with RNG site identification, per-second timing information, and a checksum to ensure data accuracy are assembled and transmitted over the Internet to a central server in Princeton, New Jersey, USA, for archiving.

The GCP network of RNGs started with a few RNGs in 1998, and it has slowly increased in size over time as individuals are found who are willing to host an RNG on their personal computer. As of May 2002, the network consisted of approximately 50 RNGs located throughout North America, Europe, South America, Asia, Africa, and Australia. The number of RNGs reporting daily fluctuates by one or two occasionally, when the computers hosting the RNG are taken offline or used for other tasks.

Analyses

> Never send to know for whom the bell tolls; it tolls for thee.
>
> —John Donne

The analyses presented here were exploratory, and as such, the results will be useful primarily in developing future hypotheses. A non-mathematical way of thinking about these analyses is as follows: Imagine that each RNG is continually generating numbers that, when collected into a histogram, form a bell-shaped curve.[2] We are interested in how the shape of this bell curve changes over time, and especially in how external events might be associated with those changes. We are, in effect, studying relationships between the "ringing" of the bell during the course of human events. To borrow John Donne's poetic phrase, we are asking for whom the bell tolls.

There are four simple ways that a bell curve can deviate from a theoretically perfect bell shape. The curve can be (1) shifted to the left, (2) shifted to the right, (3) squashed flat (i.e., the top of the bell pushed down), or (4) squashed thin (the sides of the bell pushed toward the center). The first two possibilities are not suitable for our purpose because we have no *a priori* way of predicting which direction the curve might shift (or in our metaphor, which direction the bell might swing). So our analyses focus on the second two methods.

In the analyses described below, the "variance" method is concerned with how a bell-shaped curve formed by data from all of the RNGs fluctuates from one day to the next. The "intercorrelation" method is concerned with the similarity in shapes among many bell-shaped curves, one curve for each RNG, and how those similarities fluctuate from day to day.

Variance Analysis

This analysis explored changes in variance among all reporting RNGs for each day in the year 2001. The procedure was as follows:

1) Download the daily raw data files for each day in 2001 from the GCP Web site (http://noosphere.princeton.edu/data/extract.html as of May 21, 2002). The data files are in the form of a matrix, where the columns identify the RNGs and the rows list the per-second trial outputs.
2) Calculate the daily trial mean and standard deviation for each RNG running each day. Exclude individual RNG trial values $\leqslant 50$ or $\geqslant 150$, whole RNGs with daily empirical trial means >103 or <97, or whole RNGs with daily trial standard deviations >6 or <8. Extreme individual trials and deviant daily means and standard deviations were excluded from further analysis to ensure that the data were being collected from properly functioning RNGs. This is necessary because the RNGs are physical devices connected to PCs and the Internet, and as such they are not expected to perform perfectly all the time. Still, the GCP network has proven to be remarkably reliable. In more than three years of continuously collected data, over 99.5% of the database falls within expected thresholds for truly random data. The few exceptions include RNGs with overly restricted variance (typically due to RNG circuits that failed) or an occasional impossibly high or low individual trial value (typically due to a malfunctioning PC serial port).
3) Use the daily trial mean and standard deviation for each RNG to calculate a Student t-score with 199 degrees of freedom (199 df) per RNG, per second, where $t = (x - \bar{x})/s$, x is a per-second trial value from RNG number r, $\bar{x}$ is the daily trial mean for RNG r, and s is the daily trial standard deviation for RNG r. In practice these t scores are almost identical to standard normal deviates, $z = (x - 100)/\sqrt{50}$, where 100 is the theoretically expected mean and $s = \sqrt{Npq} = \sqrt{200 \times .5 \times .5} = \sqrt{50}$, the theoretically expected standard deviation.
4) Because $t(199\text{ df}) \approx z$, calculate one t^2 value per RNG per second. These t^2 values are effectively chi-square distributed.
5) Sum the t^2 values from Step 4 across all reporting RNGs per second, keeping track of the number of t^2 values that are summed. Call this summed value T, and the number of summed t^2 values N; thus T is chi-square distributed with N df.
6) Sum 300 contiguous T values from Step 5 to form a single value that consolidates 5 minutes of the per-second data; call this value T_5. Do the same for the N values; call this N_5. Repeat this procedure to create a total

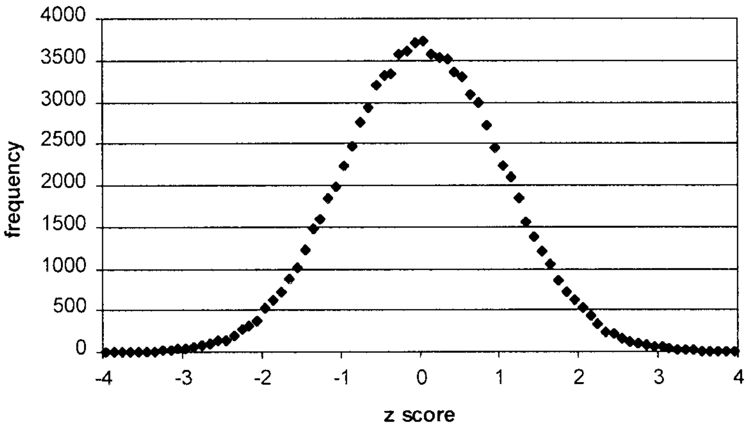

Fig. 1. Distribution of z scores associated with 5-minute summaries across all RNGs from January 1, 2001, through November 30, 2001.

of 288 non-overlapping T_5 and N_5 values per day. This step is performed to compress what is otherwise a very large daily data set (e.g., for 36 reporting RNGs, there are 86,400 seconds per day $\times$ 36 RNGs = 3,110,400 per second trials reported, vs. 288 5-minute periods per day $\times$ 36 RNGs = 10,368 data elements per day). T_5 is chi-square distributed with N_5 df.

7) Sum 72 contiguous T_5 values from Step 6; do the same for the N_5 values. Call these summed values W_{T1} and W_{N1}. Then shift right by 1, create another sum of 72 T_5 values, call these W_{T2} and W_{N2}, and so on. This procedure creates a sliding window (the equivalent of 6 hours of real-time), where the W_T values are chi-square distributed with W_N df. A total of $288 - 72 = 216$ sliding windows are created to cover each day's data.
8) Calculate a z score (standard normal deviate) for each sliding window in Step 7 as $z = \sqrt{2W_T} - \sqrt{2W_N - 1}$ (Guilford & Fruchter, 1973, p. 517), where W_T is the chi-square value and W_N is the degrees of freedom.

Variance Results

To demonstrate that over long periods of time the composite RNG variance is well-behaved, Figure 1 shows the distribution of z scores for each 5-minute segment (i.e., the T_5 and N_5 values formed in Step 6 above) for all GCP random data generated between January 1, 2001, and November 30, 2001. We expect to see a normal, bell-shaped curve with mean approximately 0 and standard deviation approximately 1, and this is what we observe.

To examine slower fluctuations in the time-varying RNG output variance, and to consolidate the data into time lengths more appropriate to the way in which humans tend to respond to important news events (i.e., in terms of hours rather

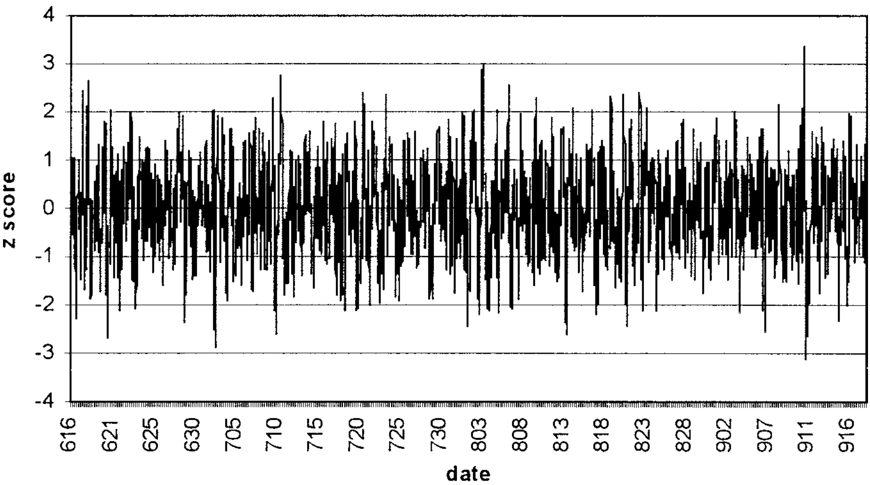

Fig. 2. z Scores associated with 6-hour sliding windows, as described in Steps 7 and 8 above, for RNG data collected between June 16, 2001 (noted as "616" on the x-axis) and September 20, 2001. This 3-month time-span was used to place the September 11 results into context.

than minutes), the data are smoothed with a 6-hour sliding window, as described in Step 8 above. Figure 2 illustrates the effects of this smoothing for data collected between June 16, 2001, and September 20, 2001. This curve may be thought of as (roughly) a visualization of the "ringing" of our bell.

The ordinate in Figure 2 is in terms of z scores. Values between $z = -2$ and $+2$ are basically noise, but values outside this range are statistically interesting. In particular, in Figure 2 notice that something unusual happened one day in September. On that day the curve deviated beyond $z < -3$ and $z > +3$. Figure 3 shows this anomaly in more detail. It happens that this curve peaks more than an hour before a jet hit World Trade Tower 1 in New York City at 8:46 AM EDT, September 11, 2001, and the curve drops to its lowest point around 2:30 PM, roughly 8 hours later.[3] A 6.5 (or greater) drop in z scores within an 8-hour period, as observed on September 11, is unique throughout the year 2001. In metaphorical terms, our bell rang more loudly on this day than any other day in 2001.

Intercorrelation Analysis

The GCP network of RNGs is analogous to a set of buoys that we scatter across an ocean to detect a tsunami, a colossal singular wave. To continue our bell motif, let's say we attach a little bell to each bouy, and we use a radio to send the sound of each bell to a central monitoring location.

Because buoys are tossed about by local currents and winds, if we listen to their collective sounds, most of the time we will hear nothing but random tinklings. However, on rare occasions the bouys will sing out as one great chord.

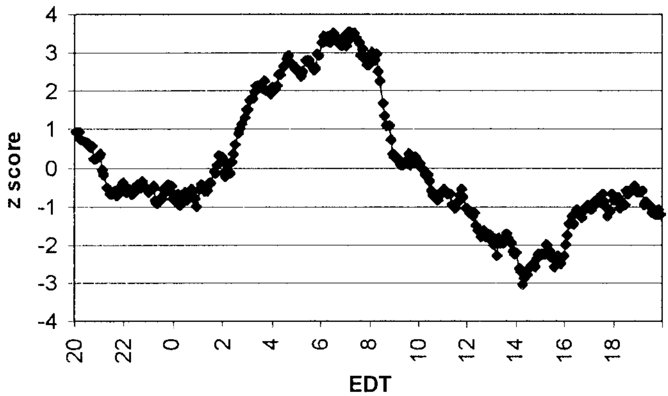

Fig. 3. Smoothed z-scores across 36 RNGs running from 8:00 PM September 10, 2001, to 8:00 PM September 11, 2001. No other day in the year 2001 showed as large a drop in z scores as observed on this day. The x-axis is in hours, Eastern Daylight Time.

During such times we have an anomalously positive correlation among all the bouys, and we have good reason to believe that a tsunami has occurred.

In a similar fashion, I examined all correlations among all possible pairs of GCP RNGs to see how they behaved on a daily basis over the year 2001, from January 1, 2001, through December 31, 2001. My expectation was that September 11, 2001, might be the GCP equivalent of a tsunami given the unprecedented degree of world-wide attention precipitated by the events of that day.

Procedure

1. For each RNG, determine z-scores as $z = (x - 100)/\sqrt{50}$ for each trial, where x is the per-second RNG trial data. The very small percentage of cases in the GCP database with known RNG data problems were, of course, excluded from this step.
2. Create a z-squared value per RNG per second.
3. For each RNG, sum 300 contiguous z-squares to create a single, 5-minute consolidation of the per-second trial, and repeat this for all 288 non-overlapping 5-minute periods per day. As in the initial variance analysis, call this sum of z-squares T_5 and the associated degrees of freedom N_5. Note that this step differs from the initial variance analysis because these 288 T_5 and N_5 values are created for each RNG separately.
4. Smooth these 5-minute segments, per RNG, using the equivalent of a 6-hour sliding window.
5. Calculate a Pearson product moment correlation r between all possible pairs of smoothed curves, among all RNGs, per day; e.g., among 36 RNGs there are 630 possible pairs.
6. Normalize each resulting r from Step 5 using a Fisher z transform, then

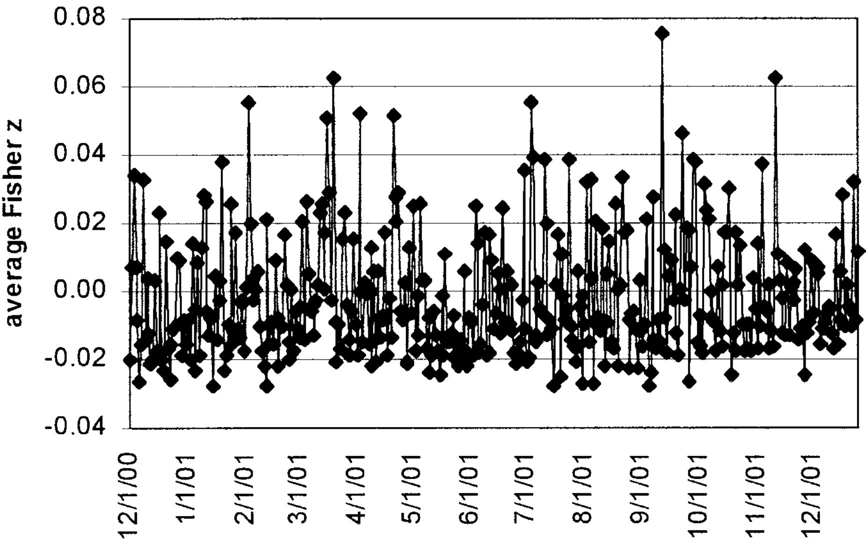

Fig. 4. Daily average RNG intercorrelations. The peak value is September 11, 2001.

determine the daily mean and standard deviation of these transformed r values.

7. Use a Student t-test to compare each day's daily mean normalized r against the null hypothesis of $r_0 = 0$.

Intercorrelation Results

Figure 4 shows the daily mean Fisher z scores (i.e., daily intercorrelation values) for each day between December 1, 2000, and December 31, 2001. Figure 5 shows the odds against chance associated with t-tests of the daily values. The peak daily value occurred on September 11, 2001. This suggests that our "bell" rang loudest on this day because of the collective simultaneous bell tones issuing from all of our RNGs around the world.

One question that may arise when examining these results is whether the large intercorrelation value observed on September 11 may have been due to unusual environmental artifacts, such as increased cell-phone usage, which affected some RNGs. If this were the case, then we might expect to see a few very high intercorrelations on that day for RNGs located in say, North American cities, but most of the other intercorrelations, say for RNGs located in the South Pacific, Australia or Asia, would be near chance. If this were the case, then we could predict that the standard deviation of the RNG intercorrelation values on September 11 would be inflated. However, Figure 6 shows that this standard deviation was unremarkable as compared to all other days; thus, from this perspective there is no compelling reason to believe that the large

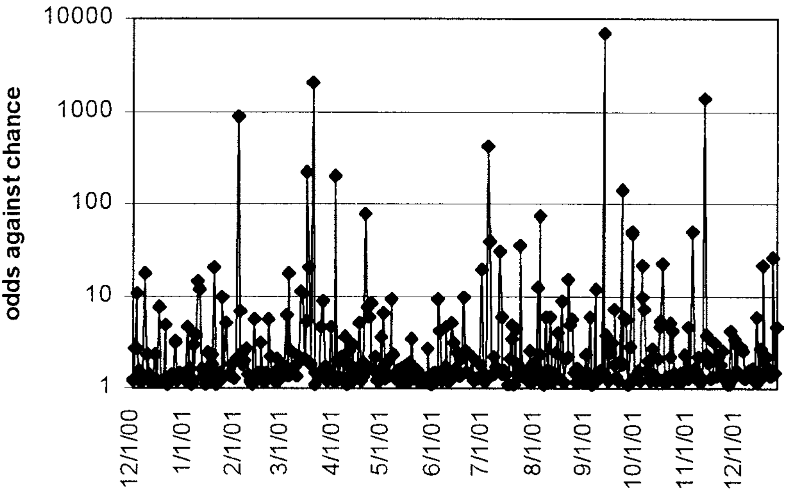

Fig. 5. One-tailed odds against chance for values observed in Figure 4.

intercorrelation observed on September 11 was due to localized environmental artifacts.

This finding is supported by Figure 7, which shows the histogram of all RNG intercorrelations on all days (the bell-shaped curve centered around 0) as compared to the histogram of intercorrelations observed on September 11, 2001 (the jagged line). The environmental artifact hypothesis predicts that the distribution of intercorrelations for September 11 would be skewed by a few large high correlations among some neighboring RNGs. Instead, the histogram shows what appears to be a normal distribution that is shifted to the right. A t-test of the mean difference between these two distributions results in $t = 3.714$, $p = 0.0001$ (one-tailed). This implies that all of the RNGs were "ringing" in unison a bit more than usual, rather than just a few RNGs ringing in exceptionally close synchrony.

One might argue that these results depend on a fortuitous selection of a 6-hour smoothing window (Step 4 in the analytical procedure). To address this possibility, I varied the window smoothing length from 5 minutes to 12 hours, then determined t-scores of the difference between the Fisher z intercorrelation means for September 11 vs. the grand mean for all other days. Figure 8 shows the results. The value $z = 3.7$, associated with the difference between the two distributions shown in Figure 7, appears on this graph at the window size of 6 hours. The analysis indicates that the optimal window length is actually about 8 hours rather than the 6 hours I employed, but more importantly it shows that all window lengths greater than 10 minutes resulted in significant differences. This suggests that the significant intercorrelation observed on September 11, 2001, was not due to a fortuitous selection of window length.

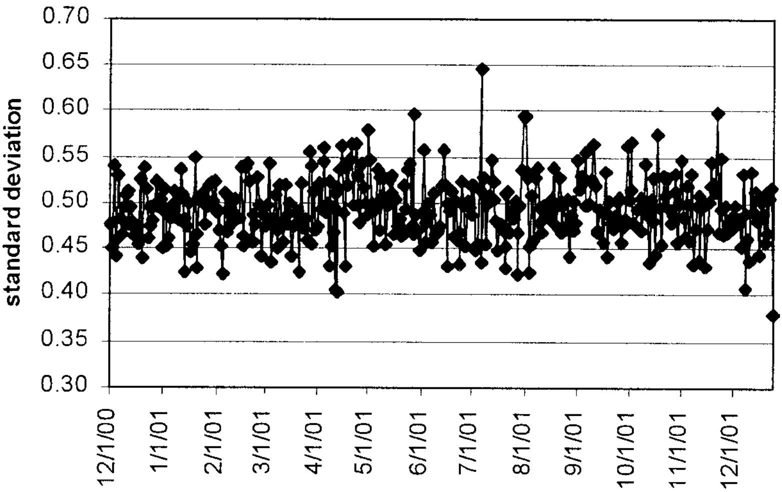

Fig. 6. Standard deviations for daily average Fisher z intercorrelations.

News Analysis Method

Given the interesting exploratory results associated with September 11, 2001, the next question I addressed was whether the GCP hypothesis would generalize to less dramatic days. To investigate this question, I examined how the RNGs behaved on 25 single-day events listed in the GCP event registry (multi-day events were excluded from this analysis), from December 1, 2000, through December 31, 2001. The GCP hypothesis predicts that the average daily intercorrelations for these days, as compared to all other days, would be significantly larger. A t-test supported the prediction, $p = 0.016$ (one-tail), and this difference remained significant after excluding September 11, 2001 ($p = 0.024$).

While this result points in the right direction, many of the events entered into the GCP registry were there because someone guessed that a given event might be associated with a change in randomness in the RNGs. While such guesses were valid because they were made in advance of examining the GCP data, one could argue that this opportunistic method of registering events overlooked many other events that also attracted mass attention, and more importantly it provokes the criticism that the method of selecting newsworthy events was too subjective.

Thus, to form an objective measure of "newsworthy events," I took all news events listed in the "Year in Review" month-by-month feature on the *InfoPlease* Web site, www.infoplease.com, for the one year period from January 1, 2001, through December 31, 2001. This Web site lists headline news in five categories: world news, US national news, and a combined business, science and society category. *InfoPlease* is affiliated with ESPN, Time, and the Reuters news

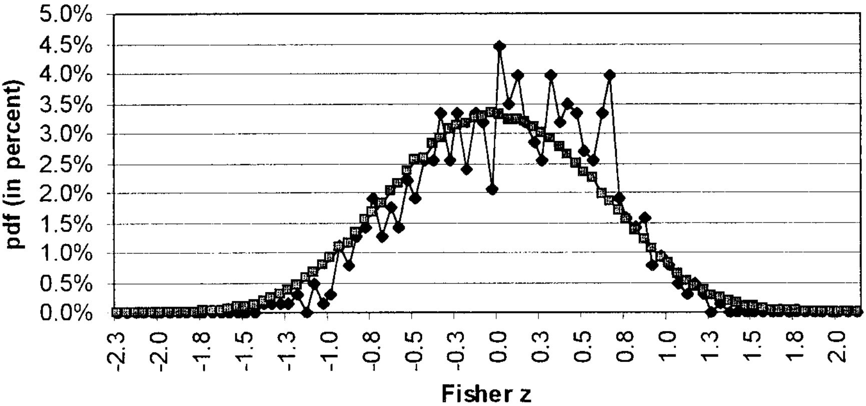

Fig. 7. Histogram for all Fisher z intercorrelations from December 2000 through December 2001 (the smooth, bell-shaped curve), and the intercorrelations observed on September 11, 2001.

service; thus, the information on the site is assumed to be reasonably accurate. Of greater importance, the news items were selected by the *InfoPlease* editors completely independently of the GCP. This Web site was selected over other potential online news sources, such as CNN, because it provides a comprehensive day-by-day list of news *events,* whereas most other sites list important news *stories,* such as "the economy," without providing day-to-day historical details.

For the 1-year test period, a total of 394 news events were listed; these took place on 250 days. The GCP hypothesis predicts that these 250 days would have a larger mean intercorrelation value than the remaining 115 non-newsworthy days. A t-test confirmed the prediction, $p = 0.011$, one-tailed.

A still more generalized way of examining the GCP hypothesis is to see whether the "amount" of daily news would be positively correlated with the daily RNG intercorrelation means. To test this idea, I observed that in the *InfoPlease* list of events, the minimum number of news events occurring on a single day was 0, and the maximum was 5. Each of those events was accompanied by a text description; the number of characters in those descriptions summed over all events per day ranged from 72 to 1,193. I used these text counts as indicators of the amount of news per day in the sense that many news events on the same day would lead to larger values. I also explored using the number of events per day as a simpler news metric (the correlation between the total number of characters per day and the total number of events per day was $r = 0.90$, so I used the text count value as the primary metric because it provided a more continuous variable to work with).

News Analysis Result

Figure 9 shows the correlation between the daily news metric and the daily mean intercorrelations. The correlation is small, but as predicted it was

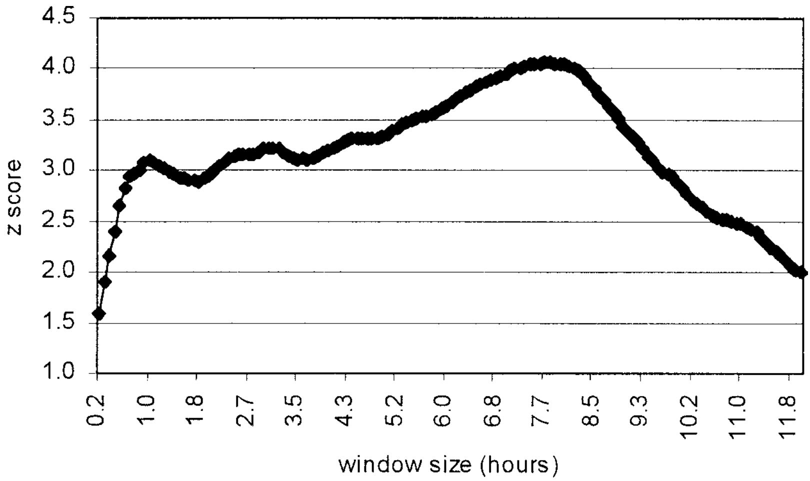

Fig. 8. Effect of window size length on differences between the distribution of all daily intercorrelation values vs. the distribution for September 11, in terms of a one-tailed *z*-score.

significantly positive: $r = 0.16$, $t(363\ \mathrm{df}) = 3.08$, $p = 0.001$, one-tailed. If September 11 is removed from consideration: $r = 0.15$, $t(362\ \mathrm{df}) = 2.88$, $p = 0.002$, one-tailed. And if all of the non-news days are removed (these are seen in Figure 9 as a column of points at 0 on the x-axis), the correlation remains significant: $r = 0.11$, $t(248\ \mathrm{df}) = 1.76$, $p = 0.040$, one-tailed. A Kendall *tau* nonparametric correlation between the number of listed news events per day vs. the daily RNG intercorrelation value was also significant: $r = 0.062$, $n = 365$, $p = 0.037$, one-tailed.

Discussion

As mentioned above, one mundane explanation for the present results is that world events that captured mass human attention were associated with unusual surges of electrical power and use of telecommunications equipment, and this in turn might have created unusual environmental conditions that influenced the RNGs. While environmentally-induced artifacts are conceivable, there are four main arguments against this explanation: (1) in the case of September 11, the cross-RNG variance peaked over an hour before the terrorist events began to unfold, (2) the RNG intercorrelations reflected common changes among RNGs located around the world, (3) the RNGs are powered by voltage-regulated computer power supplies, and many PCs are further isolated from line power through surge suppressors and battery-powered, uninterruptible power supplies, and (4) the RNGs are designed to exclude first-order biases (i.e., drifts of the mean) through the use of XOR logic.

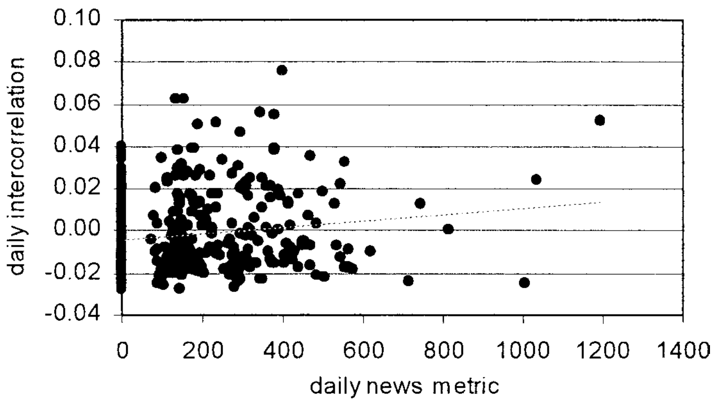

Fig. 9. Correlation between daily news metric and daily RNG intercorrelation values, p = 0.001, one-tailed. September 11, 2001, is associated with a news metric value of 398 in this graph.

These items argue against an artifactual explanation, but we can indirectly test the effects of electromagnetic interference on the RNGs by examining their outputs according to local clock time. That is, if the electromagnetic environment influenced the RNG circuits, then we would expect to see differences in RNG behavior between night and day. During the day, human use of electronic devices peaks, as does wide-spectrum electromagnetic noise, electric field strength, non-ionizing radiation, etc. During the night, all of these effects decline.

Figure 10 shows the z-score equivalent for variance across all RNGs, consolidated in 0.1-hour bins according to the local time of each RNG, over the entire month of September 2001. This graph summarizes 89.6 million 200-bit samples from all RNGs reporting in September 2001, for a total of 17.9 billion random bits. This provides enormous statistical power to identify diurnal influences, but no day-night differences or trends are observed: between 8:00 PM and 8:00 AM (night) and 8:00 AM and 8:00 PM (day), z (difference) = 0.53, p = 0.30, one-tailed. This provides no support for an electromagnetic artifact hypothesis.

Besides possible environmental artifacts and a global mind-matter interaction effect, what else might account for the observed results? One possibility is that these results might be due to chance. Another is that the results are due to a fortuitous choice of analysis methods. Follow-up tests with new data will help evaluate the viability of these possibilities.

Conclusion

Throughout history, philosophers have debated the perplexing, dualistic nature of subjective versus objective. In the 20th century, quantum theorists

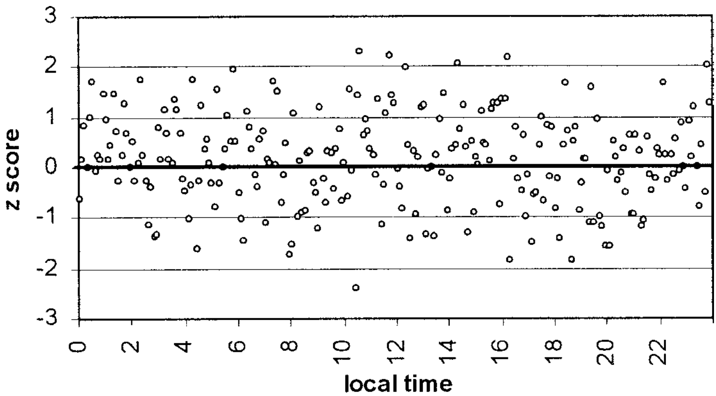

Fig. 10. RNG variance according to local time per RNG for the entire month of September 2001, in terms of z scores.

found themselves forced to seriously reconsider classical assumptions about observer vs. observed, and about mind vs. matter (Jahn, 1981; Jahn & Dunne, 1987; Stapp, 1999; Wilber, 1984). In the latter half of the 20th century, investigators developed increasingly rigorous methods for explicitly testing postulated mind-matter interactions (Radin & Nelson, 1989, in press). And as the 21st century begins, it appears that a cautious answer to the question used to taunt Bertrand Russell may be, "Yes, mind does matter." As for the observations discussed in this paper, whether they turn out to be a fluke due to the uncertainties of exploratory data analysis or something more interesting will be resolved by formalizing these analyses and testing them in future GCP data.

In sum, these analyses explored a new twist on the enduring riddle, "For whom does the bell toll?" The answer according to this analysis resonates with John Donne's words in the 16th century: "No man is an island. The bell tolls for thee."

Notes

[1] See the Web site http://noosphere.princeton.edu and Nelson (2001) for further details.

[2] More precisely, a normal distribution that approximates the underlying binomial distribution.

[3] There is no easy answer for why the peak in this curve occurred before the terrorist attacks; the observable fact is that it did.

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