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Random number generators at the ballpark: Preliminary evidence for the detection of moment-by-moment fluctuations in group attention as measured by Psigenics software

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Abstract

The field of consciousness studies seeks reliable measurement devices to detect the existence of human consciousness and its impact on the physical world. The random number generator (RNG) technology utilized by Princeton's Engineering Anomalies Research (PEAR) lab is a well-studied approach to detecting mind/machine interactions. RNG studies in the lab and in the field have showed potential in measuring a small cumulative impact of group intentionality, but have generally not been as effective in registering moment-to-moment changes in group consciousness. To that end, an upgraded adaptation of PEAR software was taken to a professional baseball game in an attempt to demonstrate RNG responsivity to in-game emotional fluxes expressed and experienced by the crowd.

Despite significant methodological limitations inherent in a preliminary demonstration such as this, statistically significant correlations between emotionally significant game events and RNG patterns were observed. Several suggestions about methodology are offered to guide further research in this area by refining our understanding of key variables in this type of protocol – what types of crowd emotions are most potent, what extraneous factors may confound data, and what mechanism of action could account for such anomalous results. These caveats aside, the protocol described in this paper appears to have potential for shedding further light on the nature of human consciousness in the group setting, and its impact on human behavior.

Key words: random number generator, RNG, Princeton's Engineering Anomalies Research (PEAR), Psigenics, group intentionality, group consciousness

Introduction

Researchers in energy medicine and consciousness studies seek to make visible that which lies beyond the five physical senses. An invisible healing force is described by all world healing traditions ('qi' in Traditional Chinese Medicine, 'prana' in yogic Ayurveda, and many other names in uncounted other healing traditions), but Western medicine has remained skeptical of its existence. Other, related phenomena seem to lie beyond the range of the space/time continuum and its known physical forces (distant prayer, clairvoyance, precognition and other so-called nonlocal processes), and are even less accepted in the Western medical paradigm. Successful detection and measurement of these elusive subtle energies seems near at hand, given advances in bioelectromagnetism, engineering and computer science.

Many sophisticated technologies have been developed in attempts to directly detect this purported subtle energy or its surrogates in human subjects. For instance, electrostatic fields are imaged via Kirlian photography (Krippner and Rubin, 1974) and the Korotkov's Gas Discharge Visualization process (Gibson, 2005); biophotons are detected via Popp's photomultiplier (Popp, 2003); meridian electrical resistance is measured with the acupoint detectors of Motoyama (Motoyama, 1997); and light wave interference is imaged in the polycontrast interference photography (PIP) of Oldfield (PIP website, web ref.). As tools to investigate energy and consciousness phenomena in clinical and research settings, these techniques all have much potential, as well as significant shortcomings with respect to reliability, reproducibility and validity (in particular, PIP).

An important line of evidence for the existence of subtle energy and nonlocal effects comes from investigating the impact of these energies on people and on inanimate objects, by assessing whether accepted physical or physiologic parameters are altered by energetic or nonlocal interventions. This type of evidence has come from studies of remote attention, also known as 'the sense of being stared at' (Sheldrake, 2003); the effect of thoughts on material substances (for example, tests of prayer's impact on water crystallization by one researcher have generated provocative images that have not been replicated by other researchers (Emoto and Thane, 2005)); and the impact of human thought on mechanical devices.

This latter category has been most thoroughly explored by the Princeton Engineering Anomalies Research (PEAR) Laboratory over the past 29 years, under the direction of Prof. Robert Jahn (PEAR website, web ref.). Using computerized random number generators (RNGs) that create a stream of one thousand randomly sequenced ones and zeroes every second (in essence, virtual coin tosses), the PEAR lab has detected reliably reproducible, if small, fluctuations from true 50/50 randomness in the distribution of ones and zeroes when their computers are targeted by the intentions of meditators in the same room. Because the unexpected results of these measurements have been replicated thousands of times by PEAR, the level of statistical significance for these mind/machine interactions has reached $p < 2x10^{-6}$ in some massed trials (Jahn and Dunne, 2005).

Roger Nelson's Global Consciousness Project (GCP) extended this work from the laboratory setting into the field by using an array of RNG units (also known as Random Event Generators, REGs) that were observed in laboratories around the world. These distant detectors have registered statistically significant fluctuations in RNG readouts during important world events, from earthquakes and New Year's Eve celebrations to Princess Di's funeral, the events of 9/11, and President Obama's election and inauguration (GCP website, web ref.). Non-random deviations in the RNGs have been repeatedly observed even though the RNGs are not in physical proximity to the events being monitored. Hence, the descriptor 'nonlocal' is used to describe these effects.

Since this body of RNG evidence appears to validate parapsychological beliefs about direct mental interaction with machines and the independence of consciousness from the space/time continuum, it is not surprising that PEAR and GCP have faced a wide range of criticism from various quarters over the years. Questions about research methodology, statistical analysis, and explanatory mechanisms have been addressed by PEAR and GCP at length in manuscripts posted on their website and in numerous publications in peer-reviewed journals. A recent editorial commentary summarizes these issues (Dossey, 2007). While an in-depth exploration of these is beyond the scope of this article, the Discussion section will address several key points about RNG methodology as they relate to the demonstration described in this paper.

One natural outgrowth of the GCP studies of mass events was the attempt to measure real-time changes in human attention during the course of any one such given event, tracking moment-to-moment changes in RNG output in addition to recording the overall cumulative impact detected by the GCP's RNGs. However, the original PEAR/GCP technology did not prove sensitive enough to respond in the moment to the rapid shifts in attention that occur during sporting events like the US football Super Bowl (Radin, 1997). This event was chosen because it involved rapid shifts in strongly expressed emotions by a large number of people - those present in the stadium and those watching non-locally on TV. This lack of clearly measurable impact of rapidly fluctuating emotions may have several explanations:

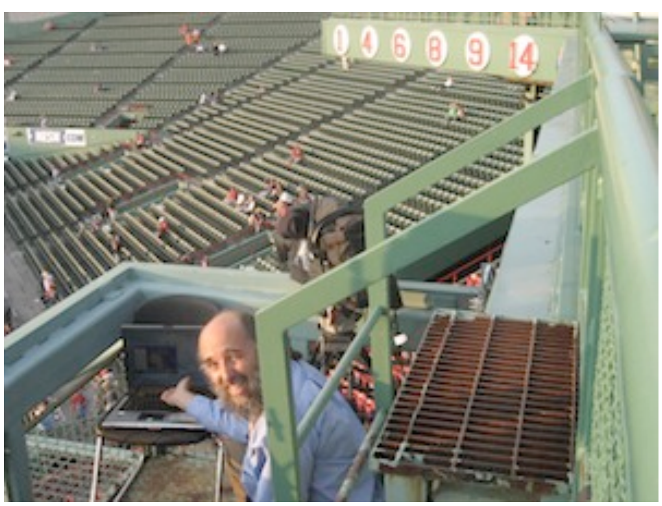
1. Competing intentions from the two rival sides cancelled out their impact.
2. PEAR instrumentation can detect small deviations from baseline randomness of the sort that accumulate slowly over time before eventually attaining statistical significance, but is not sensitive enough to detect rapid moment-to-moment fluxes in group attention.
3. No such attentional force or interaction exists with RNG devices under these circumstances.

To address this challenge, Psigenics Inc. has developed a second-generation software program to analyze RNG output that increases the speed of data generation and uses a 'psychoresponsive algorithm' to increase the signal-to-noise ratio, or bias of the data stream. - Demonstrations of this software that were not peer-reviewed (psigenics.com) suggest that it is sensitive enough to respond in real time to rapid shifts in individual and group attention. A field test of this software at a professional baseball game was recently conducted, in an attempt to revisit the question of whether this RNG technology can detect moment-to-moment fluctuations in crowd attention. The results are described below.

Methods and materials

An Acer Aspire 5610 laptop PC and an attached RNG peripheral (the ComScire QNG, Model J1000KU) were placed on a seat in the upper deck at Fenway Park in Boston, Massachusetts during a Major League baseball game between the Boston Red Sox and the Toronto Blue Jays on July 13, 2007. (The equipment setup is shown in Figure 1).

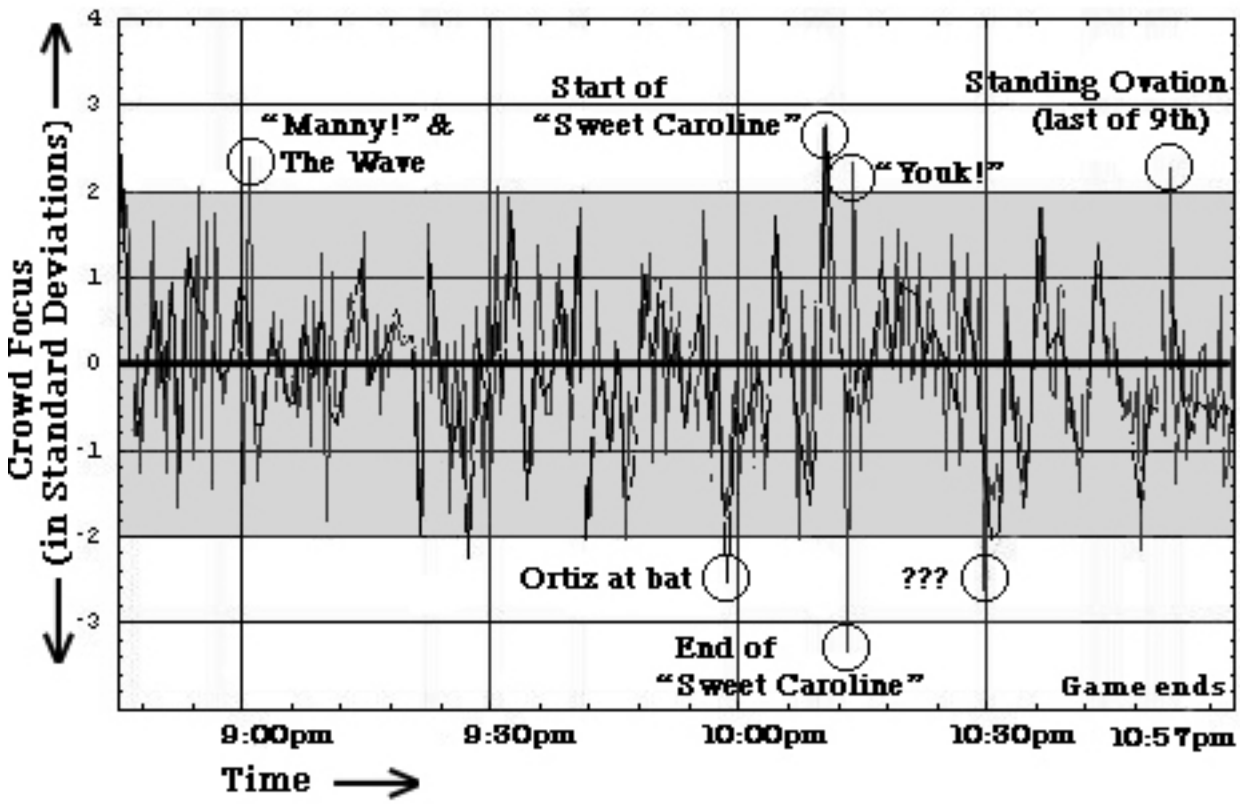
Figure 1. A laptop Random Number Generator (RNG)



The RNG device generates approximately one million bits (ones or zeroes) per second, which are processed by the software's bias-enhancing algorithm into ten clustered subunits per second. For the purpose of rendering the graphical representation shown in Figure 2, two plots whose time-averaged segments were phase-shifted by 30 seconds were overlaid, to increase the density of data points. The weighted average of these outputs were then combined into one data point per minute, the maximum sensitivity allowed by this software.

This relatively long time interval of 60 seconds was chosen by the program's developer to allow a signal of non-randomness to emerge from the background noise of randomness, given that the signal-to-noise ratio only increases in proportion to the square root of the number of samples averaged. If shorter time intervals for data epochs had been used with the current instrumentation, the analysis would be less likely to reveal any embedded bursts of non-randomness, although the trade-off would allow for more precise correlations of RNG output with event timing.

Figure 2. RNG graph



In Figure 2, the horizontal axis is subdivided into 117 subunits, representing the passage of time in the nearly two-hour (117 minute) game, from 9 pm to 10:57 pm. The RNG output is displayed on the vertical axis, with most points lying between +2.0 to –2.0 standard deviations (SD) from the baseline of complete randomness; occasional points deviate more than 2 SD's from baseline, and represent a statistically significant degree of non-randomness in that data point.

At the same time that the RNG device was generating its string of random digits, I was also in attendance at the baseball game, making notes of game events that seemed likely to have special emotional significance for the 37,000-plus fans at the game. The process for rating these events was admittedly subjective, and included such informal criteria as the volume of crowd noise (under the assumption that cheering intensity reflects the intensity of emotional involvement); personal assessment of the significance of various game situations (such as seeing a strategic opportunity arise, sensing the start of a rally); my own reading of fans' expectations and hopes to determine important moments of focused attention (for instance, ascribing audience stillness to a sense of hushed anticipation rather than to boredom).

I further stratified the significant events on a three-point scale ('possibly significant,' 'probably significant, and 'definitely significant'), again based on my weighting of these subjective criteria. I noted the time of onset of these game events with a hand-held stopwatch that had been synchronized with the computer's clock at the start of the test. Game events ranged in duration from several seconds (a strikeout, a hit) to as long as three minutes (an audience singalong), but there was no preset format for deciding into which time epoch any event was assigned if it lasted longer than 60 seconds.

During the game, I was not aware of the processed RNG results shown in Figure 2, because raw RNG data files require significant post-game analysis to create meaningful graphic output. In fact, the RNG graph in Figure 2 was prepared in Gainesville, Florida by Psigenics founder Scott Wilber several days after the game had taken place. He did not have access to my notes about game events, nor had he watched the game on television. This protocol ensured that the two streams of data were generated independently.

Results

Two data sets were generated: the computer's RNG output and my list of significant game events. The vast majority (102/117) of these time-averaged RNG data points fell within two standard deviations from the mean – the usual 95% threshold for statistical significance – and thus varied from true randomness to an extent that could reasonably be expected to arise by chance alone.

This 117 minute interval also saw 15 instances in which the RNG output equaled or exceeded 2 SD's from the mean, in either the positive or negative direction. In this same interval there were 20 game events which I felt to be significant. Fifteen of these 20 events fell in the 'possibly significant' range, 1 was felt to be 'probably significant', and 4 were deemed 'definitely significant.'

The two data sets were combined to create Figure 2. The 7 points of highest RNG non-randomness (marked by circles in the figure) were evaluated for correlations with significant game events: 6 of these 7 points were found to have occurred during a game event that had been rated as significant by me. Four occurred during 'definitely significant' game events, two during 'possibly significant' game events, and one during a non-significant moment. For example, one RNG peak in Figure 2 was temporally linked to the game's climactic final out (in the last half of the 9^{th} inning, at 10:51 pm, RNG = 2.3 SD), while several others were tied to cheers for a star batter coming up to bat in a rally (Kevin 'Youk' Youkilis at 10:14 pm, RNG = 2.4 SD; and David Ortiz at 9:57 pm, RNG = 2.6 SD).

The synchronized fan cheering behavior known as the 'The Wave' was also associated with a high RNG peak of 2.4 SD at 9:02 pm. The largest RNG fluctuation of all (3.4 SD, at 10:12 pm) occurred during another form of shared fan behavior – the sing-along (Fenway Park has developed the tradition of singing the Neil Diamond song, Sweet Caroline, at the start of the 8^{th} inning). The remaining eight statistically significant RNG points ranged in value from 2.0 to 2.2 SD; none were associated with 'somewhat significant' or 'very significant' game events.

Data Analysis

With respect to the data obtained in this demonstration, there are two important variables to assess: the presence of large RNG fluxes, and their association with game events. Five percent of the 117 moment-windows observed would be expected to deviate by 2 SD from the baseline, due to random fluctuations at the 5% significance level, for a predicted total of 5.85 such points. However, 15 points equal to or exceeding 2 SD were observed in the 117 minute period being analyzed. Chi square testing (observed = 15, expected = 5.85, 1 degree of freedom) shows that the probability of this distribution occurring randomly is highly unlikely, with $p<.000001$ [($p=7.6x10^{-7}$), $X2=14.21$, df=1.

The single largest RNG spike of 3.40 SD has a probability of nearly 1000 to 1 of occurring due to chance alone; the odds of one such divergent point occurring anywhere among 117 data points is thus 8.55:1, which is unusual but not rare. But when such an aberrant reading occurs synchronously with a significant and infrequent independent event, and when a series of similar temporal correlations accumulates, the odds increase dramatically that these are not random correlations.

To be specific, three of the four 'highly significant' game events happened during the same 60-second time interval as one of the seven statistically most significant RNG spikes. A combinatorial analysis of this distribution determined that the difference between the p-values of a Fisher's exact test of the results that were observed and of the results that were expected was statistically significant, with a probability of $p=.000481$ that these were chance associations. That is, these results are statistically highly significant, with $p<.0005$ that they can be explained by the null hypothesis of no connection between game events and RNG readings.

Discrepant data

In several important ways, the two data sets did not inter-correlate as predicted. For example, several moments that were deemed by me to be emotionally highly significant were unaccompanied by RNG spikes larger than 2 SD (for example, a rally-ending strikeout at 10:42 pm, and a rally-starting single at 10:45 pm). And as previously mentioned, a very large RNG flux of –2.7 SD occurred at 10:30 pm, at which time I had noted no significant event whatsoever occurring.

The GCP database of continuous global RNG monitoring showed no significant deviations at that particular moment in time (GCP website for 7/13/07, web ref.); no major discrete world events happened that evening, per GCP criteria. Only one of their 65 field RNG units recorded any significant deviations during the 15 minute interval from 10:30 pm to 10:45 pm EST, and the composite RNG score for that interval was a statistically insignificant 0.27.

No significant RNG fluctuations occurred when another song, Take Me Out to the Ball Game, was sung at 9:49 pm. A post hoc analysis of this disconnect might note that Take Me Out to the Ballgame is a generic baseball song which doesn’t engender the strong emotional response at Fenway Park that the uniquely Bostonian Sweet Caroline sing-along does.

But this assumption that two similar songs will have different emotional impacts highlights the risk of retrospective analysis and post hoc attribution, and points to the need for a more adequately regulated method of assigning event/RNG connections. The discordances between RNG output and game events described here may reflect my own inability to accurately discern important attentional shifts in the crowd, or they may validate the null hypothesis that that there is no causal connection between RNG readings and game events. Major improvements in methodology are required to more definitively address this question, and can be attained by implementing the suggestions that follow.

Problems of methodology

RNG software: The Psigenics software has not been widely accepted in the RNG field and is thus open to criticism. It is described by its developer as being able to increase the information rate 1000-fold over earlier RNG models via the use of a so-called bias amplifier algorithm. Descriptions of this software, the circuit diagram for the RNG generating unit, and a statistical explanation of the randomness algorithm are all in the public domain on the Psigenics website (Psigenics website, web ref.) and have been shared with other RNG research teams.

The Psigenics data collection uses true random bit generators whose output is then modified by a subsequent bias amplification algorithm that effectively increases the signal-to-noise ratio. This bias amplification formula, and a detailed comparison with PEAR's methodology, are described in an unpublished paper, Machine-Enhanced Anomalous Cognition that is available online (Psigenics whitepaper, web ref.). The mathematical modeling described therein outlines the relationship between the bit rate, the amount of intentional influence by the operator/participant and the ultimate hit rate of output trials; the analysis is beyond the scope of this review (ibid).

The Psigenics approach generates and displays discrete RNG readings (in units of SD; equivalent to PEAR's sigma units) for each minute of the study, rather than presenting the results of the gradual accumulation of sigma effects as are presented during the course of a typical PEAR run.

The generator used in this study has an output bit rate of 1 Mbps (megabyte per second); more recently developed generators have bit rates up to 819 Gbps (gigabytes per second), with concomitant increases in detection sensitivity.

The smoothing of data for graphical presentation involves taking all the output data in non-overlapping blocks of time of equal length (one-minute blocks) and combining them to produce a single output of normal numbers representing the response during the corresponding time block.

Several research papers on the general topic of mind/machine interactions can also be accessed at the Psigenics and PEAR websites. However, at present no independent studies of the Psigenics methodology have been published in the research literature.

To increase the validity of data generated by future RNG/ballpark studies, the following methodologic problems must be addressed.

1. *Multiple evaluators*: At any given ballgame, multiple evaluators could independently rank game events for purported emotional or attentional significance. An averaging process to determine the most significant events could be used to filter out individual subjective bias. This will improve the precision of the independent variable and generate more reliable ratings of game events by using weighted group averages rather than potentially idiosyncratic individual reports.
2. *Independent assessment of correlations*: The use of an independent blinded evaluator to assess correlations between RNG data and game event ratings would further minimize subjective bias in the assignment of event/RNG correlations.
3. *Multiple game recordings:* The compilation of a series of recordings at multiple games during the course of a season would help to determine the significance of any emergent data patterns. Unanswered questions include the meaning of positive versus negative RNG fluctuations, and the importance of the emotional quality of the crowd's reactions (disappointment vs. happiness, quiet anticipation vs. active expression, etc.).
4. *Decibel monitoring:* Continuous monitoring of crowd noise levels during the game via a decibel meter would allow for reliable assessment of the possible influence of noise as either a confounding factor, or as a surrogate marker for emotional intensity. Though not likely to be causal, noise volume would be an easy to track correlated variable.
5. *Computer shielding:* If the laptop computer is more effectively shielded from noise, physical vibrations, and putative ambient electromagnetic fields (EMFs) by placing it inside a cushioned and sound-proofed Faraday Cage, then data reliability is further enhanced by eliminating these possible confounding variables. If any RNG correlations are detected by an EMF-screened

computer, then clearly the EMF mechanism of action is not applicable, and other nonlocal mechanisms must be considered.

6. *Accurate time notation:* The onset and duration of significant game events was reported in 10-second increments, even though game events typically last from 5 seconds to 3 minutes in duration, with longer events clearly overlapping several such successive time segments. In contrast, the RNG data points were averaged over 60-second intervals, the current limit of computer sensitivity. More accurate timing of game events and the use of shorter time intervals for RNG data points (to whatever degree is permitted by future generations of software) would increase the strength of any correlations because a much more precise combinatorial analysis could be performed.

Mechanism of action

Apart from these methodological limitations, there still remains the challenge of defining a mechanism of action to explain apparent correlations between RNG output and game events. Since the findings from PEAR's and GCP's research are so counter-intuitive, the lack of an obvious explanatory mechanism has been a significant obstacle to more widespread acceptance of their findings. Two potential mechanisms of action for these mind/machine interactions include local electromagnetic field (EMF) effects and nonlocal quantum effects.

The EMF mechanism is superficially appealing as a possible explanation of subtle interactions between fans and players. Cortical and cardiac electrical activity can generate local EMF oscillations that are reflected in EEG and EKG recordings; the rhythmically oscillating cardiac field may be strong enough to influence not only the EEG of the subject's own brain (McCraty, 2003) but also the EKG of nearby persons (McCraty, 2003; Leskowitz, 2009). Therefore, the power of a coherent group EMF could theoretically have a resonant impact on players' EMFs, EKGs and perhaps even performance level.

Any potential impact of this putative fan EMF output is complicated by the existence of several other nearby sources of large ambient EMFs, such as from radio waves generated by nearby fans listening to the game on their radios and at nearby sports bars, and the continuous but fluctuating output of EMF, RF and microwave radiation from the unusually large cluster of hospitals located within blocks of Fenway Park. However, ambient EMFs can have no influence on RNG production, because the hard drive and software of a computer's central processing unit are insulated from ambient EMFs by virtue of the laptop's modular solid-state construction.

Furthermore, since EMF strength decreases inversely with the square of the distance from its source, EMFs clearly cannot generate the nonlocal results described by PEAR and GCP. Recall that RNG devices need not be in physical proximity to the event being studied in order to record statistically significant correlations. For that reason, the GCP website posts ongoing real-time recordings from their array of units around the world, and notes correlations with historical events, as they occur, anywhere on the planet. In this same nonlocal vein, brain measurements like EEG and functional magnetic resonance imaging (fMRI) have successfully detected the effects of distant intentionality. Thoughts directed at a subject/receiver over long distances have a measurable impact on the subject/receiver's brain function (Achterbert, 2009). Hence, EMFs are unlikely mediators of these effects.

RNG researchers invoke quantum processes to explain how a field of consciousness may connect mind to machine. Jahn proposes "a molecular model of mind/matter manifestation" with an attendant "vector representation of its subliminal seed regime" to understand what he calls the "complementarity of consciousness" (Jahn, 2001). Radin theorizes that "quantum entanglement" is the mechanism by which distant physical processes remain interconnected, by analogy with the well-documented process of subatomic photon entanglement (Radin, 2006). Tiller has advanced a “multidimensional gauge-invariant model” linking intention, consciousness and subtle energies (Tiller, 1997).

The absence of a conclusive explanatory mechanism for RNG findings is another incentive to extend the preliminary demonstration described in this paper.

Implications and future research

Many questions remain unanswered at this early stage in this unfolding field of study:
1. What is the significance of positive versus negative SD fluctuations (the graphic peaks versus valleys)?
2. Why did some major fluctuations occur when no significant game event seemed to be happening?
3. Do different emotions have a different impact on RNG output?
4. Will RNGs be able to detect the 'vibe' of a place even when people are absent, such as the pre-game 'buzz' or the post-game 'afterglow'?
5. Is it possible to use RNGs to measure the 'aura' of a place that is deemed by many to be special, or even sacred? For example (Nelson, 1998), For example, GCP’s field recordings in the King’s Chamber of the Great Pyramid of Cheops reached a significance level of $p < 0.0008$.
6. Most importantly, what might be the effect of these subtle energies on team athletic performance, and how might they be manipulated to maximize their beneficial impact? In this vein, a recent study found that group focus on positive emotions can engender changes in heart rate variability (HRV) in a nearby subject in sensory isolation (Leskowitz, 2009). Because this aspect of HRV, known as heart coherence, has been associated with increased psychophysical coordination (McCraty, 2003), it is possible that the fans’ enthusiastic expression of positive emotions could facilitate the players’ attainment of heart coherence. This coherence might help the athletes enter more readily into 'The Zone' of optimal mind/body alignment and enhanced athletic performance.

Appropriate methodology is now available to resolve these unanswered questions.

Summary

It appears possible that second generation RNG computer software may be responsive enough to moment-to-moment fluctuations in the emotions and attention of large groups of people at a sporting event that its output correlates to rapidly unfolding game events. The preliminary demonstration described in this article suffers from many significant shortcomings in research methodology, all of which can be rectified in future studies that are more rigorously designed along the lines suggested in this paper.

The novel methods of presenting and analyzing RNG data used in this study may represent an important option for use by future researchers, if they can be replicated and validated. It seems important to pursue this line of work, for if group attention can indeed have a demonstrable effect on individual and group physiology and behavior (McTaggart, 2007), the implications for human health and performance are considerable, even as the mechanism of action await further elucidation.

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