Princeton University

CONSCIOUSNESS AND ANOMALOUS PHYSICAL PHENOMENA

Brenda J. Dunne and Robert G. Jahn

Princeton Engineering Anomalies Research
School of Engineering and Applied Science
Princeton University, Princeton, NJ 08544

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This report is intended as an introductory summary of the purpose and history of the PEAR laboratory, its major experimental and theoretical results over the first sixteen years of research activity, and some pragmatic and philosophical implications thereof. Some portions of the text have been published elsewhere, and more detailed technical documents are available to supplement most of the qualitative segments.

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ABSTRACT

Several million experimental trials investigating the ability of human operators to affect the output of various random physical devices have demonstrated small but statistically significant shifts of the distribution means that correlate with operator intention, exhibit repeatable idiosyncratic individual variations, and display consistent patterns of gender dependence, series position development, and internal distribution structure. These effects also appear to be statistically independent of distance and time. In a complementary program of remote perception studies, experimental protocols and analytical scoring methods have been developed to demonstrate and quantify information acquired by individuals about distant geographical locations without the use of normal sensory channels. A wave-mechanical approach to modeling consciousness/environment interactions, based on a metaphorical application of quantum concepts and formalisms, has proven useful in predicting and interpreting the empirical findings and in guiding the development of more incisive experiments.

Philosophical and Historical Background

The advancement of human knowledge, both individual and collective, devolves from the dynamic interplay of two complementary processes of consciousness: experience, and conceptualization. Throughout life, consciousness accumulates experience, either incidentally or by design, and then endeavors to represent, interpret, and apply it to prediction of, or accommodation to, future events. Anomalies, i.e. incidents that contradict common experience or established belief, insert some dissonance into this dynamic, challenging first the validity of those events and then, if verified, the prevailing pattern of convictions, until some credible resolution can be achieved. The scientific method is just a particularly disciplined form of this instinctive human process. Experiments performed under rigorous controls provide empirical data on the phenomena of interest; theories, formed by a combination of deductive and intuitive conceptualization, metaphorical representation, and mathematical formalism, are composed to explicate or predict the empirical effects. Anomalies, encountered either as experimental observations that are inconsistent with prevailing theory, or as theoretical predictions that conflict with established data, stand like road signs, signaling "wrong way" to the scientific travelers, forcing design of more incisive experiments, or revision of extant models.

Most anomalous phenomena that confront scientific logic tend to have only local impact within their particular disciplinary contexts, and to arise and be resolved relatively quickly compared to the overall evolutionary paces of those fields. In rarer instances, such as the anomalous celestial observations that contradicted the prevailing geocentric models, or the array of atomic-scale physical anomalies that precipitated the quantum revolution, their implications can extend much more broadly, and efforts toward their resolution can become more widespread, protracted, and intense. The one genre of anomalous human experience that has dwarfed all others in endurance, ubiquity, implications, and resistance to rational comprehension involves some of the most basic processes of consciousness upon which its observational and deductive skills are based. Throughout recorded history, anecdotal instances of inexplicable consciousness-related anomalies have regularly been reported and variously catalogued as "miracles", "magic", "intuition", "alchemical transmutations", "psychic phenomena", or "gremlins", along with countless other categories of elusive experiences, but little coherence has ever been established among them. Yet, these incomprehensible events have had immense influence on human culture, stimulating the development of religious doctrines, ethical conventions, and even scientific methodology.

Virtually all of the ancient and medieval sciences were inseparable admixtures of rigorous analytical thought and intuitive metaphysical inspirations, and the latter components did not entirely disappear with the dawn of modern scientific methodology. Francis Bacon, father of the scientific method, proposed systematic investigation of telepathic dreams, psychic healing, transmission of spirits, and the force of the imagination on the casting of dice (Walker, 1972). Isaac Newton regarded the ultimate mechanism of change in the universe to reside in "the mystery by which mind could control matter" (Kubrin, 1981). The establishment of the British Society for Psychical Research in 1882 attracted participation by many eminent scholars, among them the likes of Henry Sidgwick, Frederic W. H. Myers, Lord Raleigh, Sir. J. J. Thompson, William McDougall, Edmund Gurney, Sir William Crookes, Sir William Barrett, Henri Bergson, Arthur, Earl of Balfour, Gardner Murphy, G. N. M. Tyrell, Charles Richet, Gilbert Murray, and William James. A comparable fascination with the role of consciousness in the physical world runs through the philosophical writings of many of the patriarchs of quantum theory, including Max Planck, Niels Bohr, Albert Einstein, Wolfgang Pauli, Werner Heisenberg, Erwin Schrödinger, Louis de Broglie, Arthur Eddington, James Jeans, Eugene Wigner, and David Bohm, among others (Jahn and Dunne, 1983b, 1987). The relationship between mind and matter has also pervaded the history of philosophy, anthropology, and psychology, and now evidences growing implications for contemporary biology and medicine. Not least of all, many of the tools of statistical analysis, which undergird virtually all contemporary scientific endeavors, were originally developed to facilitate investigation of psychic phenomena (Richet, 1884).

Given this long academic heritage, it is not totally surprising that study of consciousness-related anomalies is now emerging in various aspects of modern engineering. As contemporary information, energy, and materials technologies press toward ever more sensitive components and intensely interactive systems, it becomes necessary to protect against a broad array of extremely subtle external influences and internal interferences. Under such circumstances, indications that human consciousness may be capable of more than passive interaction with delicate information processing tools raise serious questions about the potential vulnerability of much modern instrumentation, control, and operational equipment to inadvertent or intentional disturbances associated with the consciousness of their human operators. From a more positive perspective, those same possibilities may also offer exciting opportunities for more responsive and creative human/machine technologies.

PEAR Laboratory

In an effort to address these concerns and opportunities, the Princeton Engineering Anomalies Research (PEAR) laboratory was established in 1979 under the direction of the Dean of the University's School of Engineering and Applied Science (RGJ) and the laboratory manager (BJD). The overarching premise of this program has been that the same ultra-precise technologies that might be impacted by such consciousness-related effects might also offer effective means to study them rigorously and systematically. In particular, the capacities of modern microelectronics to operate at very sensitive signal levels and to provide very rapid data acquisition, processing, and display, may permit experimental access to extremely delicate domains of interaction where such subtleties of the human/machine relationship may be explored with sufficient precision and statistical replicability to verify the effects scientifically, and to explore their correlations with salient physical and psychological parameters.

The program comprises three distinct but interrelated components. The most substantial of these is a body of experiments in human/machine interactions in which the outputs of a variety of well-calibrated random physical devices are examined for evidence of influence of their operators' intentions (Dunne and Jahn, 1992, 1993; Dunne, Nelson and Jahn, 1988; Jahn and Dunne, 1987; Jahn, Dunne and Nelson, 1987; Nelson, Bradish, Jahn and Dunne, 1994; Nelson and Dobyns, 1991). A second domain of investigation addresses the development of analytical techniques to assist in the quantification and correlation of data acquired in remote perception experiments, wherein individuals attempt to obtain information about remote geographical locations by anomalous means (Dobyns, Dunne, Jahn and Nelson, 1992; Dunne, Dobyns, and Intner, 1989; Dunne, Jahn and Nelson, 1983; Jahn and Dunne, 1987; Jahn, Dunne and Jahn, 1980; Jahn, Dunne and Nelson, 1987). The third portion of the PEAR agenda attempts to develop theoretical models capable of accommodating the empirical anomalies within an expanded scientific framework (Jahn, 1982; Jahn and Dunne, 1987; Jahn, Dunne, and Nelson, 1987). All of these programs have been described in detail in the extensive series of archival publications and technical reports referenced. Here we attempt to provide only a brief overview of the results of seventeen years of such study in this laboratory.

Despite its engineering context and perspective, the broader implications of this work for the basic scientific paradigm, for the fundamental philosophical question of mind/matter interaction, and for the individual and collective cultural dynamic have been continually acknowledged and to some extent developed. These more comprehensive purposes have been enabled by the interdisciplinary character of the PEAR staff, which includes individuals with a variety of academic perspectives including psychology, physics, and the humanities, as well as electrical, mechanical, and aerospace engineering. It has also benefitted from its residence within a liberal university, and from its association with a number of broadly based scholarly organizations.

Human/Machine Anomalies

Given the subtle nature of the phenomena under study and the myriad of environmental, physical, and psychological factors that may bear on their incidence, the technical difficulties of rigorously addressing anomalous human/machine interfaces under controlled laboratory conditions are formidable. The strategy we have employed is similar to that utilized in many modern physics experiments, where very subtle processes are observed only via the traces they leave on some well-understood background field. In our case, a variety of random physical devices have been carefully designed, constructed, and instrumented, and then extensively calibrated to establish their nominal performance. Each of these is capable of rapid generation of very large bodies of data with clearly defined statistical characteristics that can be transcribed into both on-line quantitative recordings and attractive analogue and digital feedback displays. The experimental protocols then require human operators to generate data in three interspersed sequences, under pre-recorded intentions to shift the means of the output distributions to higher values, to lower values, or to generate undisturbed baselines, with all other conditions held constant. Thus, the primary variable in these experiments is operator intention, and effects are claimed only when statistically significant correlations between those intentions and changes in the output distributions are replicably observed.

Consistent with our technical orientation, we have emphasized the generation of large databases by a relatively small number of individuals. The approximately 140 operators who have participated in these experiments have all been anonymous, uncompensated volunteers, none of whom claims any exceptional abilities in this regard; in fact, many have been self-proclaimed skeptics. While this approach has largely precluded any systematic study of the psychological or physiological factors associated with the human operators, it has provided databases comprising several million experimental trials that have permitted comprehensive and reliable statistical assessment of a broad range of physical variables. The statistical methods employed have been primarily of the classical parametric variety, although some Bayesian methods have also been utilized, and some ad hoc special methods developed (Dobyns, 1992; Nelson, 1994).

For brevity, this paper will draw primarily from the extensive results of just one of the many PEAR experiments, that involving a particular microelectronic random event generator (REG) described in detail in the references (Dunne and Jahn, 1993; Jahn, 1982, 1985; Jahn and Dunne, 1986, 1987; Jahn, Dunne, and Nelson, 1987; Nelson, Bradish, and Dobyns, 1989; Nelson and Dobyns, 1991; Nelson, Dunne, and Jahn, 1984). This REG utilizes as its source a commercial electronic noise diode whose output is rendered by appropriate circuitry into a string of randomly alternating binary pulses. A typical experimental *trial* consists of 200 of these pulses, produced at the rate of 1000 per second, and displayed to the operator as the number conforming to a regularly alternating +,-,+,-,... sequence, where the theoretical expectation for the mean of any given trial is 100 with a standard deviation of 7.07. (In essence, the process is akin to flipping 200 coins very rapidly, and counting the number that conform to an alternating sequence of heads and tails.) An alternative graphic feedback mode displays a growing cumulative deviation of trial counts from the theoretical expectation over the course of a *run*, defined as a sequence of 50, 100, or 1000 trials. A given run is usually produced automatically by a single button push, although a manual option is also available. A full *series*, which is the basic statistical unit for analysis of these experiments, consists of a pre-determined number of trials produced under the three intentions to generate high numbers, low numbers, or undisturbed baselines. Over the evolution of this experiment, various series lengths have been explored, ranging from 1000 to 5000 trials per intention.

Clearly, the first question to be addressed is whether any evidence can indeed be found that human intention can actually affect the output of such a device. The initial results of one operator's efforts, consisting of 5000 trials (1 million samples) generated under each of these three intentions, are displayed in Figure 1 in the form of cumulative deviation graphs that serially compound the accumulated excess or deficiency of binary counts compared to the theoretical expectation. In this format, all three traces display the appropriate stochastic meandering to be expected from such a random process. However, while the baseline trace remains close to the theoretical expectation indicated by the solid central line, the high- and low-intention data accumulate small but systematic deviations from chance as the data compound, eventually exceeding the 5% statistical tail probability, indicated by the dashed parabolas, to achieve a composite effect unlikely by chance at $p = 3x10^{-7}$ (Jahn and Dunne, 1987; Jahn, Dunne, and Nelson, 1987).

This initial result raises a hierarchy of questions that have essentially defined the PEAR REG experimental program throughout, such as:

a) With what consistency can this operator repeat the accomplishment?

b) Can other operators achieve comparable results?

c) To what degree do the results depend on various secondary parameters of the protocol?

d) Are other structural details of the data observable and instructive?

e) Is there any evidence indicating learning or decline effects?

f) To what degree are the results dependent on the physical characteristics of the machine?

g) To what degree do the results depend on the proximity of the operator to the machine, or the time of its operation?

h) How do the combined efforts of more than one operator reinforce or reduce the effect?

i) Are any gender-related disparities evident?

j) Can any productive operator strategies be identified?

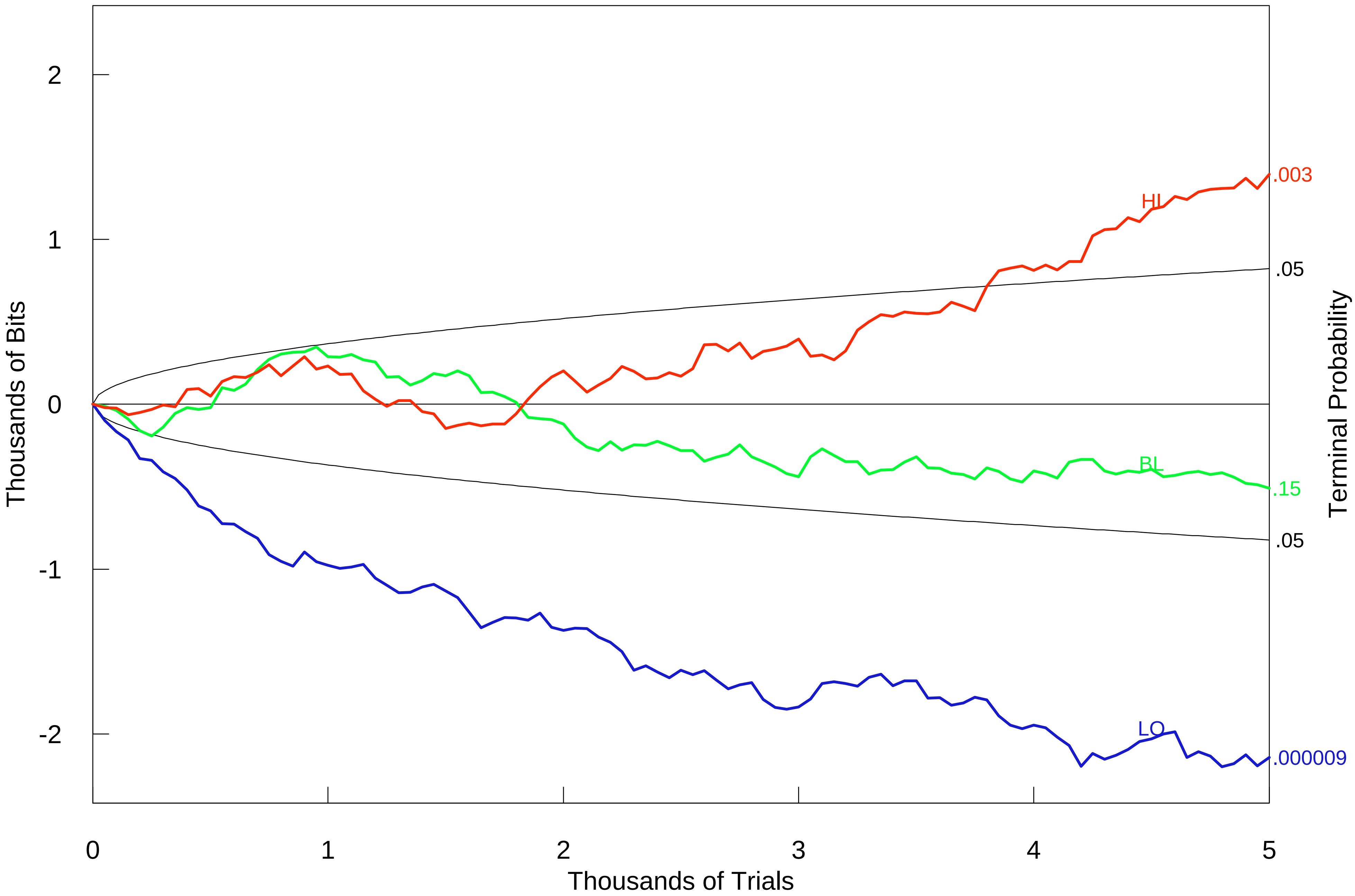

Figure 1: REG Cumulative Deviations from Theoretical Mean, Opr 10, First 5000 Trials

k) Can similar anomalies arise in group applications?
The responses of the experimental results to such queries range from definitive to equivocal:

a) Consistency

Figure 2 summarizes the results of all the data generated on this device by the same operator as reported in Figure 1 over a period of approximately twelve years, comprising 62 independent replications in the form of individual experimental series, and amounting to over 120,000 trials (24 million samples) per intention. Within the intrinsic statistical noise, these overall results indicate a modest but persistent achievement that is well beyond any reasonable chance expectation. Despite variations of many secondary protocol parameters, such as run length, mode of assignment of intention, manual versus automatic trial generation, or sampling rate, as well as the inevitable range of psychological moods and environmental conditions subsumed over so long a period, the intentional efforts display clear secular trends in the desired directions, while the baseline remains close to the theoretical expectation. The overall mean shifts are quite small: +0.095 in the high efforts and -0.666 in the low, but the replicability of these effects compound to highly unlikely chance probabilities of $p = 2 \times 10^{-6}$ for the high efforts, 5×10^{-4} in the low, and 10^{-8} for the composite effect in the direction of effort. Of the 62 series, 45 (73%) produce high-low splits in the direction of effort, ten (16%) of which exceed the $p = .05$ probability criterion. The baselines, in contrast, seem almost too well behaved, with an overall mean of 99.994 ($p = .244$) and none of the series means exceeding the 5% chance expectation, although some six or seven of them would be expected to do so by chance (Dunne and Jahn, 1993).

b) Other operators

Over this same twelve-year period, 91 different operators generated a total of 522 series, comprising nearly 2.5 million trials, following the same basic protocol. While none of these have contributed databases as large as that of the operator represented in Figures 1 and 2, several have produced larger absolute effect sizes (mean shifts). Many others have demonstrated similar but lesser correlations. A few operators have produced results opposite to intention, and others show results statistically indistinguishable from chance. A large number of operators demonstrate better performance in one intention than in the other (usually in the high direction), and a few produce significantly distorted baselines. In several cases, individuals who show no strong overall correlations with intention are nonetheless found to respond in repeatable, individually characteristic fashions to deliberate variations in the secondary parameters of the experimental protocol (Nelson, Dunne, and Jahn, 1984; Dunne, Nelson, and Dobyns, 1988; Nelson and Dobyns, 1991). The internal replicability of several of the larger individual databases has led to the concept of operator "signatures" on this and similar experiments.

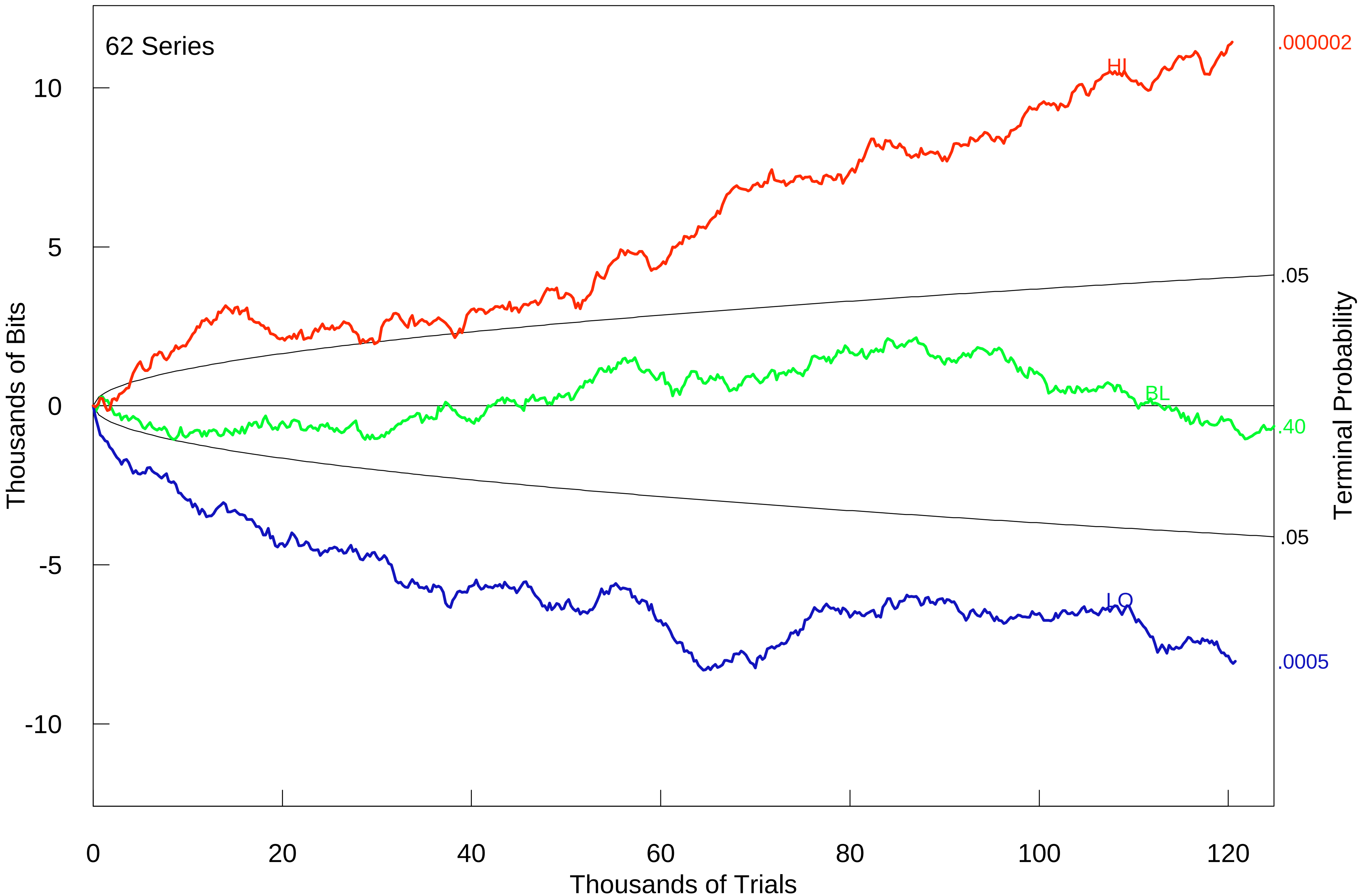

Figure 2: REG Cumulative Deviations from Theoretical Mean, Opr. 10, All Local Data

c) Secondary parameters

A comprehensive regression-based analysis of variance applied to the entire REG database confirms that the primary variable of operator intention is highly significant ($p=5x10^{-4}$), but reveals no significant overall correlation with any of the other parameters explored (Nelson and Dobyns, 1991). The absolute effect sizes produced by all 91 operators are found to distribute normally, but with a displaced mean, with a majority of the participants contributing to the total effect (Dunne, Nelson, and Dobyns, 1988; Dunne and Jahn, 1993; Jahn, 1995). Despite all the variabilities among individual operators' performance, their combined results, presented in Figure 3, compound to a persuasive overall effect.

d) Statistical details

The huge databases produced in the course of this and other PEAR experiments allow examination of longitudinal trends and internal data structures for other indications of consistent or repeatable patterns which may offer insights into the underlying physical nature of these consciousness-related anomalies. One such pattern emerges in the structure of the individual trial count populations that comprise the output distributions. In all cases where significant overall effects have been demonstrated, the proportional changes in the counts from their chance expectations are found to scale linearly with the difference between the count value and the theoretical mean. In the high-intention successes, a majority of the counts over 100 show clear excesses, while the lower numbered counts display similarly consistent deficits; in the low-intention successes, the reverse pattern prevails. As shown in Figure 4, these trends can be fit by significant first order linear regressions (Z_1), with little higher order distortion (Z_2), suggesting that the basic effects are analytically tantamount to small changes in the elemental binary probabilities underlying otherwise random distributions (Jahn, Dobyns, and Dunne, 1991). In cases where there is no effect, the count populations show no such regular patterns, but display random arrays of count excesses and deficits.

e) Series position effects

Another informative indicator is the relative yields in sequential series produced by operators who generated five or more independent replications. Statistically significant tendencies are observed for operators to produce better scores over their first series, then to fall off in performance in their second and third series, and then to recover to some intermediate levels during their fourth, fifth, and subsequent series. No such trends appear in the calibration data, or in the baseline experimental data where the operator exerts no directional intention (Dunne et al, 1994). These series position patterns thus appear to be primarily psychological in origin, and may subsume the rudimentary "decline effects" frequently reported in the parapsychological literature. The apparent stabilization of effects following this early series transient period also suggests that their generation are not subject to the traditional learning curves observed in most cognitive processes.

Figure 3: REG Cumulative Deviations, All Local Data

f) Device dependence

Although the phenomenon is clearly operator-dependent, it appears to be much less device-dependent. The REG noise source has been replaced with similar and different microelectronic units, with little effect on the character of the results. A hard-wired pseudorandom source also yielded significant correlations with operator intention, although results produced using a computer-generated pseudorandom algorithm have proven more ambiguous (Nelson and Dobyns, 1991). Even a large-scale random mechanical cascade apparatus and a large linear pendulum display marginal but statistically significant operator-specific correlations with pre-stated intentions, of similar scale and character to those seen in the microelectronic REG (Dunne, Nelson, and Jahn, 1988; Nelson et al, 1994). Despite the fundamentally different random noise sources involved, individual operator results often show remarkably similar and enduring patterns of achievement across these experiments, along with similar count population and series position behaviors (Jahn, Dobyns, and Dunne, 1991; Dunne et al, 1994).

g) Distance and time dependence

The dependence of such anomalous effects on the physical distance of the operator from the machine could be an important indicator of fundamental mechanism. In fact, no such dependence has been found over the dimensions available in the laboratory itself. More remarkably, these operator/machine aberrations continue to manifest in a substantial body of REG experiments wherein operators are physically separated from the devices by distances of up to several thousand miles. The results of some 396,000 trials per intention conducted under this "remote" protocol (Figure 5), wherein the device is run at prearranged times by staff members who remain blind to the operators' intentions, are very similar to those of the local experiments, including the scale of effect, the majority preference for the high-going intention rather than the low, and the statistically repeatable operator-specific patterns of achievement. Over these global distances, no statistically functional dependence on the degree of separation has been found (Nelson and Dobyns, 1991; Dunne and Jahn, 1992).

Even more provocative is a subset of this remote REG database, comprising some 87,000 trials per intention, in which the operators were actively addressing their intentions to the machine's operation at times other than those at which the data were actually generated. Such "off-time" experiments have ranged from 73 hours before to 336 hours after machine operation, and display a similar scale and character of anomalous results to that of the locally generated data, including series position effects and count population distortions. In fact, as can be seen in Figure 6, the overall effect size in the high-intention efforts in these "off-time" remote experiments is twice as large as that in the "on-time" remote data, although this difference is not statistically significant due to the smaller size of the off-time database (Dunne and Jahn, 1992). As with the distance separations, no dependence of the yield on the magnitude of the temporal separations is observed. Comparable remote and off-time results have also been demonstrated on the random mechanical cascade and the pendulum experiments (Dunne, Nelson, and Jahn, 1988; Nelson et al, 1994).

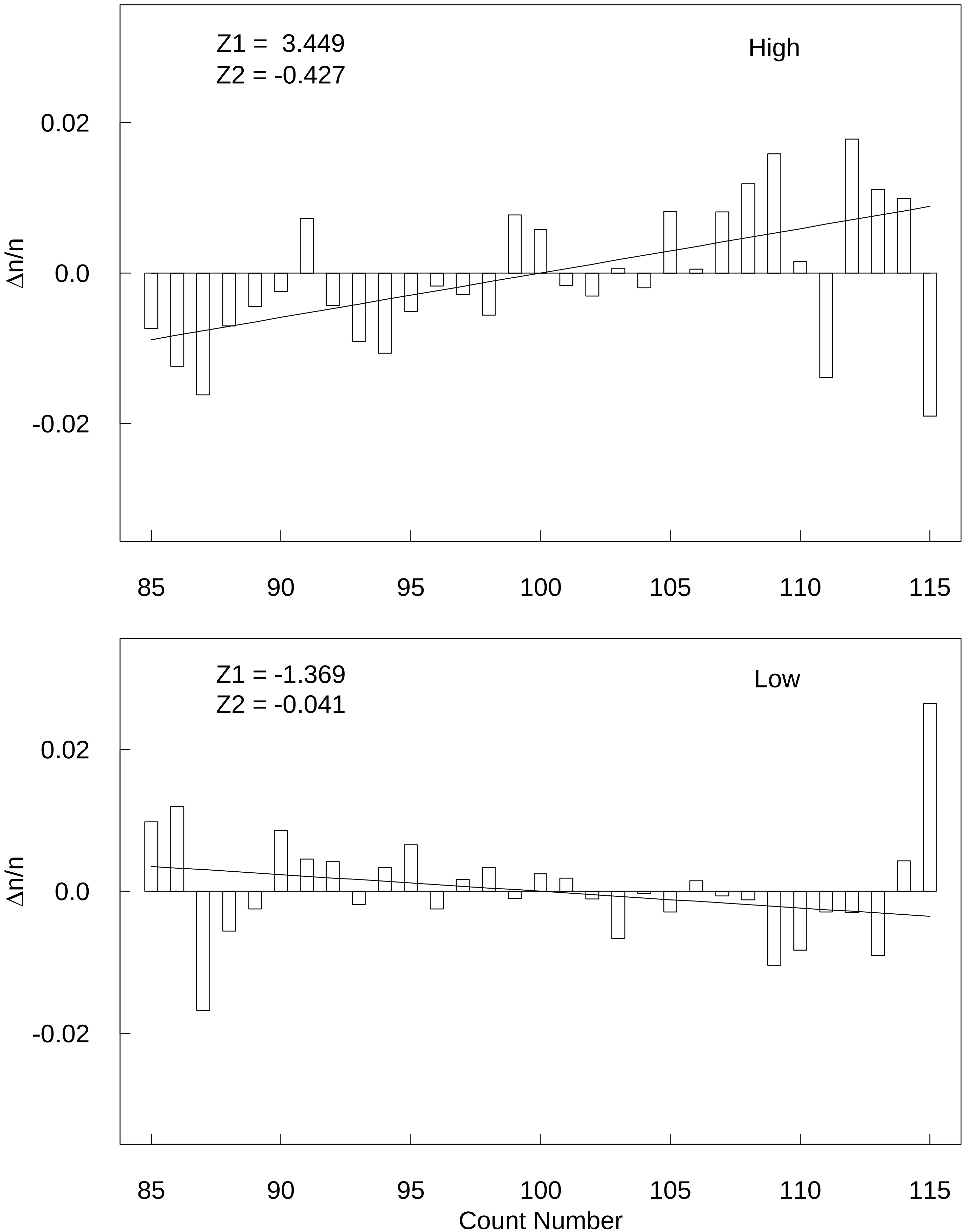

Figure 4: REG Proportional Count Deviations, All Local Data

h) Co-operator effects

Given the individuality of the operator effects, logical questions arise about combinations of operators. In another ongoing experiment, the combined efforts of two operators, each of whom has previously established an individual pattern of achievement, are being studied for evidence of superposition or reinforcement of the individual effects. While this database is so far much less extensive than that of the single operators, some general characteristics can already be identified. For example, it appears that anomalous co-operator results occur with similar frequency to those of the individual efforts, but in replicable patterns unique to the particular operator pair, rather than in any simple combinations of the individual achievement patterns. The overall results of some 85,500 trials per intention generated by 15 co-operator pairs under this protocol are statistically indistinguishable from those of the single operators, although the effect sizes are actually slightly larger.

Of considerably more interest, however, is a significant correlation with the combinations of operator gender. Namely, the results produced by eight same-sex pairs are opposite to intention in both directions of effort, while those of seven opposite-sex pairs are significantly positive in both directions of effort, with an average effect size nearly four times larger than that of the single operators. Four opposite-sex "bonded" couples produced even more striking results, with an average effect size twice that of the unbonded opposite-sex pairs, and nearly six times that of the same eight individuals operating alone (Figure 7). In addition to this unanticipated correlation with gender, the opposite sex co-operator data also display better symmetry in the scales of the high and low-going efforts, compared to the asymmetrical results typical of the single operator databases (Dunne, 1991).

i) Male/female disparities

These gender-specific cooperator results prompted a comprehensive re-evaluation of all single operator data to assess the relative individual performances of the male and female operators. Although the composite REG database of the 41 female operators shows a stronger overall yield than that of the 50 males, this was found to be primarily attributable to the contributions of three highly successful female operators. On an operator by operator basis, however, only 34% of the females succeeded in separating the high and low efforts in the desired direction, compared with 66% of the males, a highly significant difference, with a probability against chance of 7×10^{-4}. The females also display a tendency to produce high-going baselines, with 68% of them generating means greater than the theoretical expectation, compared with only 52% of the male operators. On average, the females produced larger databases with larger effect sizes than the males, but their data are much less symmetrical and considerably less correlated with their stated intentions. Similar gender distinctions are observed in the remote REG data, as well as in the local and remote data produced on the random mechanical cascade and pendulum devices. Thus, it would appear that the bulk of the high-low asymmetry observed in the composite databases is gender driven (Dunne, 1995).

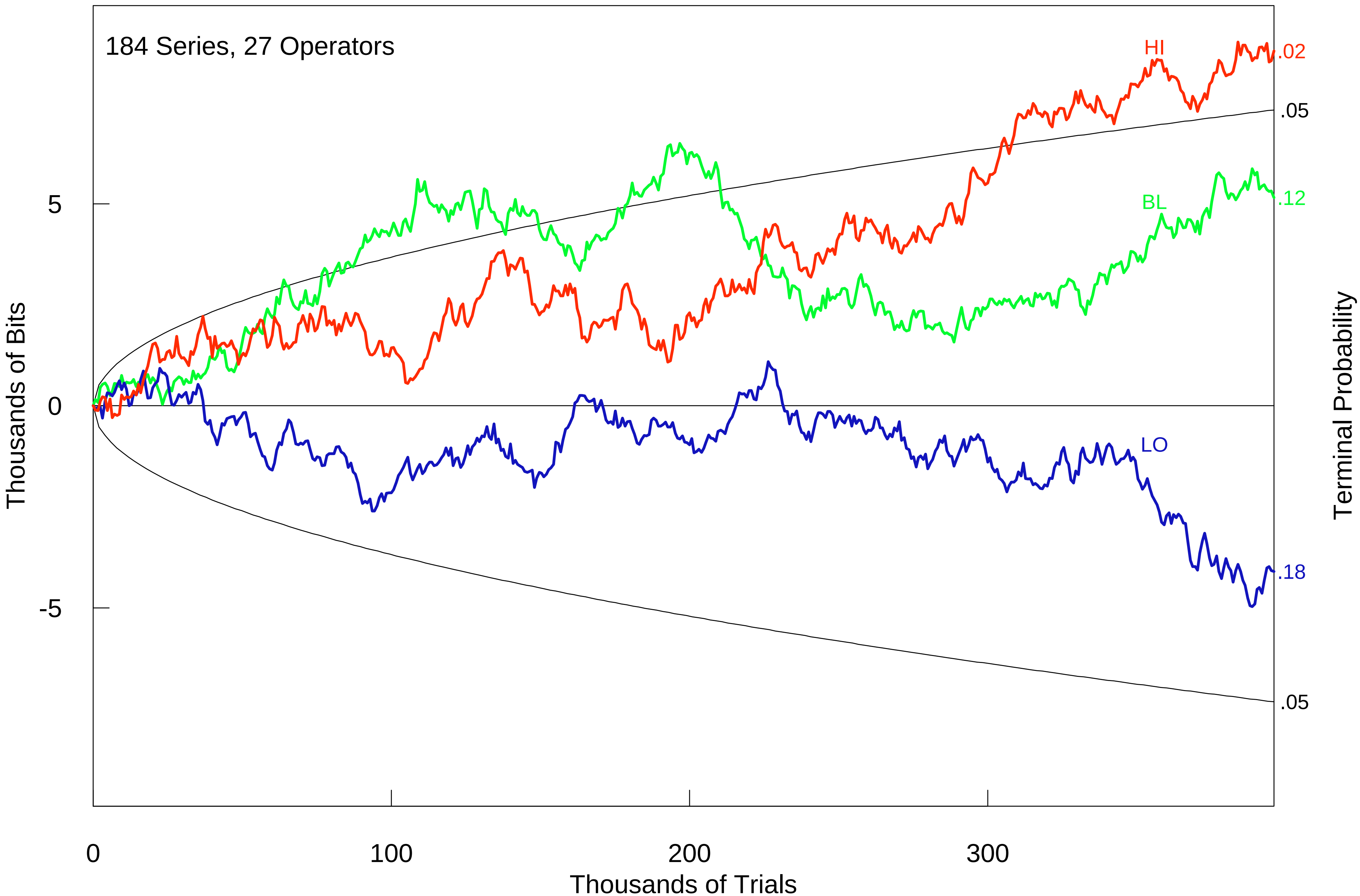

Figure 5: REG Cumulative Deviations from Theoretical Mean, All Remote Data

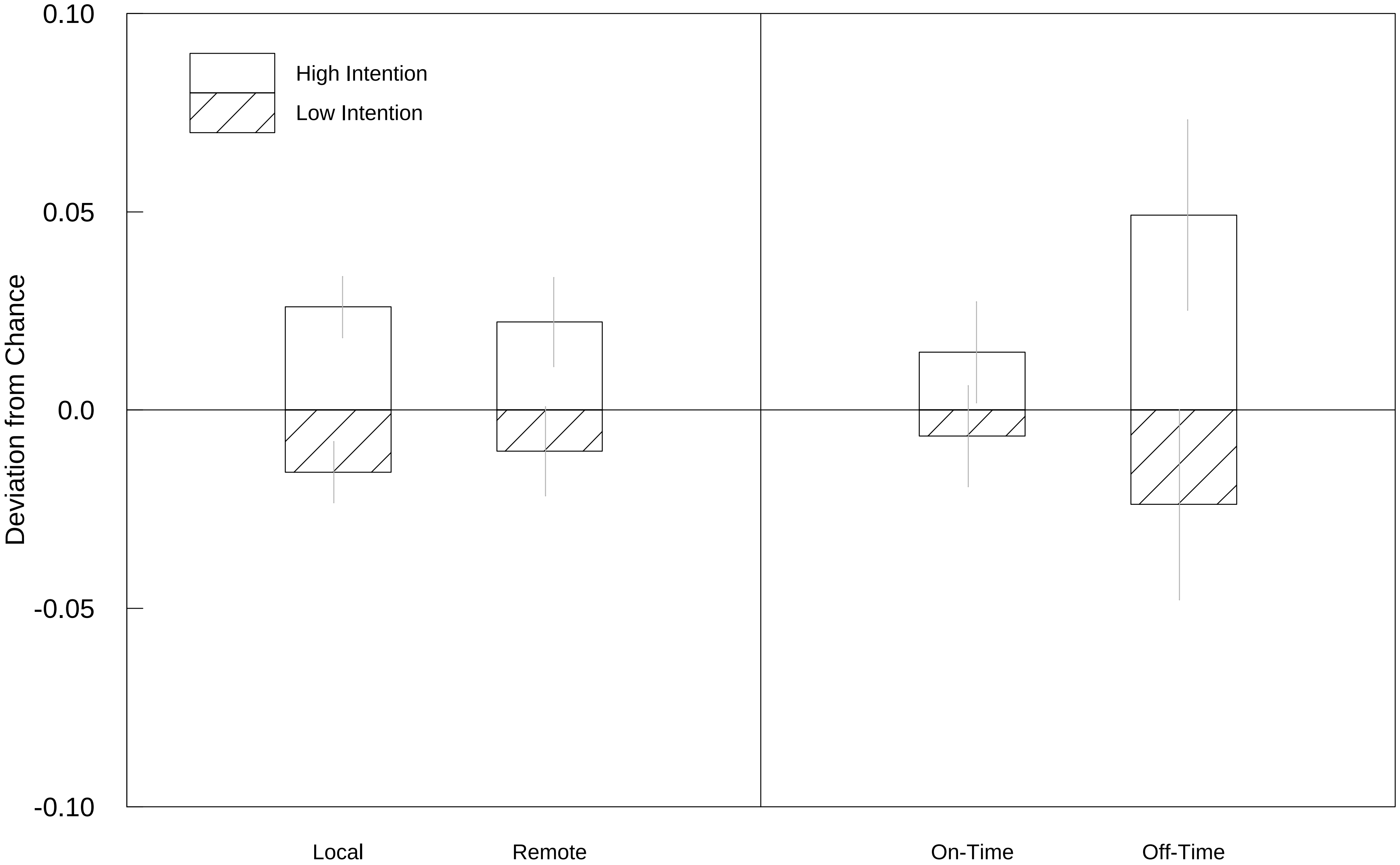

Figure 6: Effect Sizes in Local and Remote REG Experiments

j) Operator strategy

Although we have not undertaken systematic assessment of any of the multitude of potentially relevant psychological parameters characterizing the operators who have generated these effects, on the basis of informal discussions, casual observations of their styles, occasional remarks they record in the experimental logbooks, and our own experiences as operators, it is clear that individual strategies vary widely. Some operators invoke meditation or visualization techniques or attempt to identify with the device or process in some transpersonal context; others deploy more assertive or competitive strategies. Some concentrate intently on the process; others are more passive, maintaining only diffuse attention to the machine and diverting their immediate focus to some other activity, such as glancing through a magazine, or even dozing. We find little pattern of correlation of such strategies with achievement. Rather, it appears that the operational styles are also operator-specific, and often transitory; what works well for one does not necessarily help another, and what works on one occasion may fail on the next. If there is any commonality to be found in this diversity of strategy, it would be that most effective operators tend to speak of the devices in frankly anthropomorphic terms, and to associate successful performance with the establishment of some form of bond or resonance with the device, or with some self-sacrificial immersion in the machine operation.

k) Group applications

The co-operator effects suggest further extension of the REG experiments into larger group environments such as professional symposia, business meetings, ritual assemblies, or sporting events. For this purpose, a portable random event generator with software to index and record continuous sequences of data in field situations have been deployed in several venues, each of which subdivides naturally into temporal units, such as sessions, presentations, or days. Statistical assessment of examples drawn from ten applications, appropriately corrected for multiple analysis, shows a number of individually significant segments whose collective probability against chance occurrence is $2x10^{-4}$. Interpretation of these "FieldREG" findings remains speculative at this point, but logbook notes and anecdotal reports from participants suggest that high degrees of attention, intellectual cohesiveness, shared emotion, or other coherent qualities of the groups tend to correlate with statistically unusual deviations from theoretical expectation in the data sequences. Of perhaps even greater import is the feature that in virtually all of these deployments the participants were addressing no conscious attention to the REG unit, and in many cases were unaware of its existence. This clearly raises questions about the role of deliberate intention in such interactions, and may implicate more fundamental aspects of consciousness than heretofore considered (Nelson et al, 1995).

Taken in ensemble, these myriad results of the human/machine experiments and analyses clearly testify to a subtle but proactive role for consciousness in the behavior of random physical systems. Although the absolute size of the effects is very small -- equivalent to the correlated inversion of a few bits per ten thousand in the random strings -- the associated shifts of the distribution means for databases of this size are not only well beyond chance expectation, they are also well beyond the tolerance of many modern engineering control and information management systems. Not least of all, they are also considerably larger than many of the established effects that form the basis of modern physical theories.

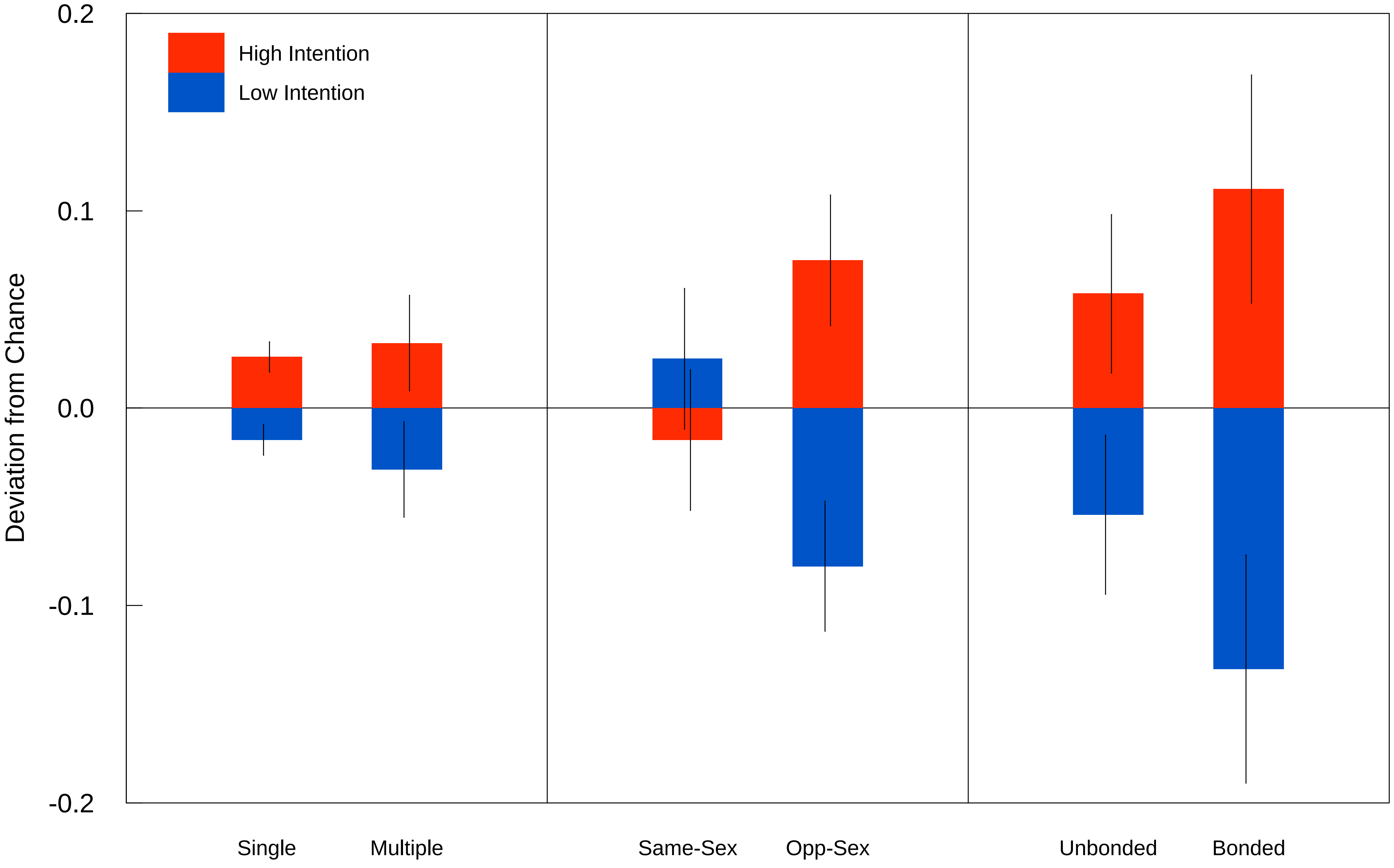

Figure 7: Effect Sizes in Co-Operator REG Experiments

Remote Perception Experiments

The second major component of the PEAR program addresses a phenomenon termed remote perception. In this class of experiment, the "target" is not a physical device or process in a laboratory environment, but a physical scene at some remote geographical location; the goal of the human participant is not to insert information into the target, but to extract information from it, by anomalous means. Two participants are involved in the basic protocol. One, the "agent," is physically present at the randomly selected target location and is immersed cognitively and emotionally in the scene. The agent's impressions are recorded photographically and in a verbal narrative that is subsequently rendered onto a standard check sheet. The other participant, the "percipient," located many miles from the scene and with no prior knowledge of it, attempts to perceive aspects of its ambiance and detail, and then records those impressions in a free-response narrative or sketch, and on the same standard check form. The agent and percipient check sheets are subsequently digitized, and their degree of consonance scored numerically by a variety of algorithms. The results, indicative of the amount of anomalous information acquisition, can then be arrayed in quantitative statistical formats similar to those used in the human/machine experiments.

Although we have collected data from several hundred such remote perception trials, the primary focus of our efforts has been the development of incisive analytical techniques to quantify the anomalous information acquired in these experiments and to guide the design of more effective experimental protocols. All of the methods employed ultimately yield distributions of perception scores that can be compared with empirical chance distributions for the same scoring recipes. As sketched in Figure 8, both score distributions correspond closely enough to Gaussian forms to allow parametric statistical evaluation of the mean shifts and higher moments, much as in the human/machine experiments. Despite the smaller size of the remote perception database, the statistical significance of the mean shifts of the score distributions are considerable greater than for the human/machine experiments, with probabilities against chance ranging from 10^{-6} to 10^{-12}, depending on the particular data subset and scoring method employed (Jahn, Dunne, and Jahn, 1980; Dunne, Jahn, and Nelson, 1983; Jahn and Dunne, 1987; Jahn, Dunne, and Nelson, 1987; Dunne, Dobyns, and Intner, 1989).

The remote perception data do not appear to display the same gender-related biases as the human/machine experiments; if anything, the female percipients achieve slightly better scores on average than the males, although the differences are statistically minute. However, the structural details of these remote perception results are qualitatively quite similar to those of the human/machine data, and the effect sizes are again statistically independent of the distance between the percipient and the target, up to ranges of several thousand miles. They are also independent of the time interval between the perception effort and the agent's immersion in the target, up to several days before or after. The score frequency distributions again display significant linear trends, suggestive of a slight but uniform improvement in the statistical likelihood of the percipients' proper identification of each of the target descriptors beyond their normal chance occurrence (Jahn, Dobyns, and Dunne, 1991). Such similarities in the results of the superficially dissimilar human/machine and remote perception experiments suggest that both draw from some common underlying mechanism rooted in the essence of information exchange between consciousness and its physical environment.

Theoretical Modeling

Any attempt to set forth a theoretical model to complement such experimental data in a traditional scientific dialogue is an awesome epistemological task. Not only are the empirical effects keenly anomalous in the present scientific framework, but in their demonstrably participant-specific characteristics they clearly involve important subjective parameters not readily accommodated by scientific language, let alone by scientific formalism. Beyond this, the results are inescapably hyper-statistical, i.e., they involve a folding of the personal and collective statistical variations in participants' anomalous and normal performances with the statistical behavior of the physical systems. By way of further complication, the series position sensitivity of the results, along with the lack of superposability of individual operator effects demonstrated in the co-operator experiments and FieldREG applications, imply strong non-linearities in the underlying mechanisms. And finally, the demonstrated lack of dependence of the phenomena on distance and time must strain any model rooted in classical physical theory. Our problem is to capture the essence of this spectrum of anomalous characteristics in some generically applicable model.

Before attempting this, it might behoove us to reflect a bit on the evolution of scientific conceptualization of physical experience. Most early science, from the Egyptians and Greeks through the Renaissance and Enlightenment, tended to focus on the behavior of tangible *substance*, its gross mechanics, chemistry, and physical properties. Midway through the 19th Century and well into the 20th, the concept of *energy*, of many forms -- mechanical, electrical, thermal, chemical, nuclear, etc. -- became more central to scientific and technological endeavor. Most recently, over the past few decades, a third physical currency, *information*, has taken center stage and clearly will dominate basic science and its applications over the foreseeable future. Superficially, these three physical domains of substance, energy, and information might seem to be quite distinct, but in point of fact, they are demonstrably fungible, with immense consequences. Einstein's identification of the transmutability of matter and energy in the nuclear realm has impelled much of 20th century physics, and the technological, political, and sociological implications thereof can hardly be overstated. Less well celebrated at present, but also clearly demonstrable, is a similar transmutability of energy into information, and vice versa, as manifested in chemical bonding, statistical thermodynamics, and basic information theory. Although this equivalence is somewhat more subtle, it well may drive much of 21st century science and many arenas of its application.

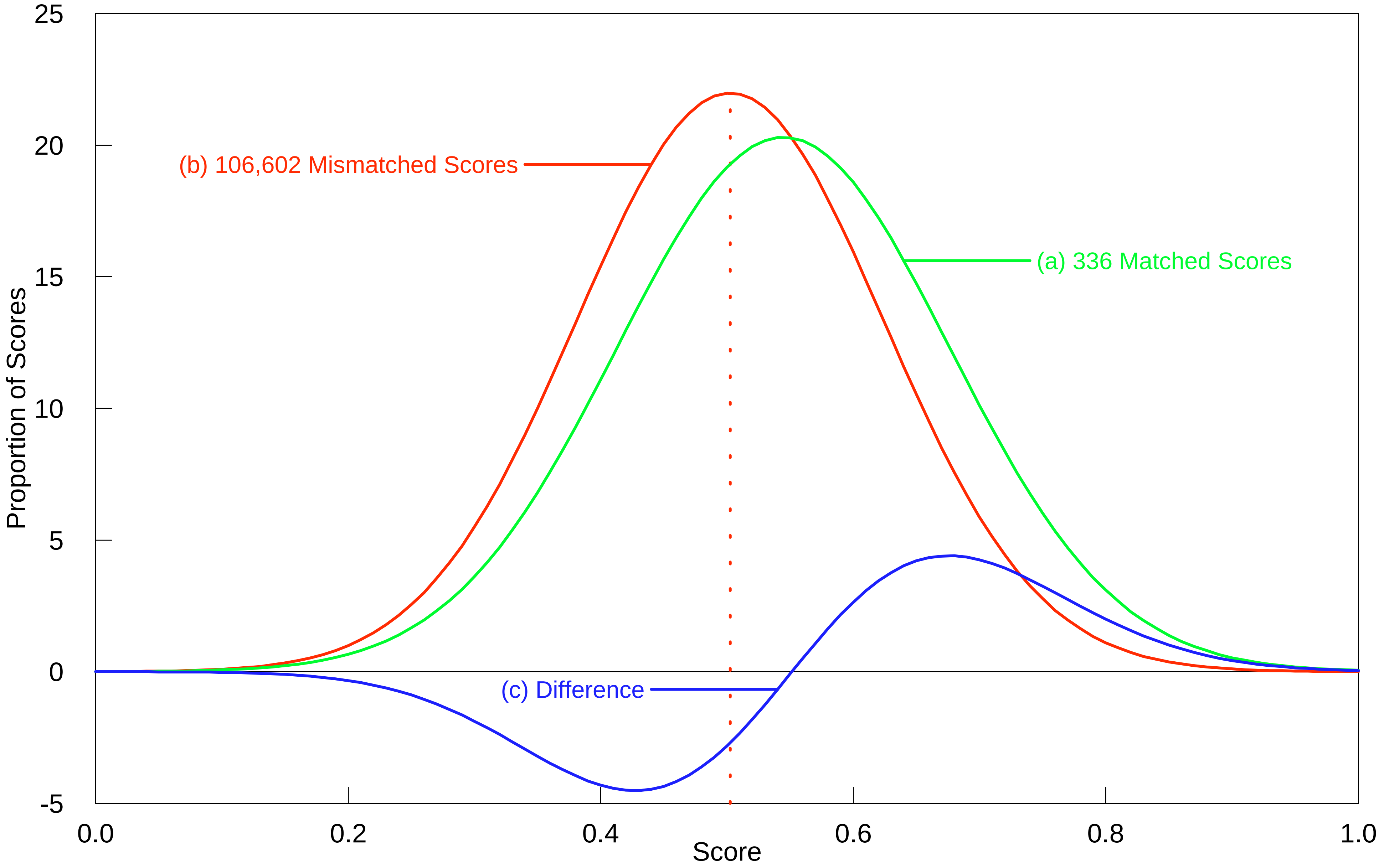

Figure 8: Gaussian Fit to Remote Perception Scores Compared with Empirical Chance Distribution of Mismatched Scores

This entry of science and technology into the kingdom of information brings with it two intriguing problems, neither of which have been fairly acknowledged, let alone addressed. First, there is the self-evident distinction between *objective* and *subjective* information. The former, the hard currency of information processing devices of all kinds, is thoroughly and uniquely quantifiable. For example, the *objective* information contained in any given book could in principle be quantified by digitizing each of its letters and every aspect of its syntactical structure. But the magnitude of *subjective* information the book presents clearly depends on the native language, previous knowledge, cultural heritage, and the values, priorities, and prevailing mood of its reader, and thus would seem to defy quantization. Similarly, while we might attempt to digitize the information displayed by a brilliant sunset or a magnificent waterfall in terms of its distributions of optical frequencies and amplitudes, in so doing we would totally fail to specify the beauty of the scene or its emotional impact. In a certain sense, we might say that consciousness acquires information in subjective form; science attempts to objectify and quantize that subjective experience.

The second complication to the coming science of information resides in the proactive capacities of human consciousness not only to acquire information, but also to *create* it, for example via traditional artistic and scholarly accomplishment, and via the "anomalous" processes that underlie the experimental results sketched above. When we shift from being "onlookers" to "actors" in the great drama of information, to paraphrase Niels Bohr (1961), we change the name of the game immensely. Instead of simply acquiring and utilizing information, we are now generating it, and with that capability comes all manner of opportunity, and a much deeper level of responsibility.

From all of this it follows that any model we erect to represent our experimental anomalies must somehow incorporate this proactive consciousness with both its objective and subjective capabilities, along with the informational characteristics of the physical world with which it is interacting. The only hope is to approach the modeling task at a very basic and rudimentary level. As a start, we might recall the four salient ingredients that pervade all of the research outlined above:

1) A random physical system, e.g. a machine driven by some random physical process, or an array of physical details embodied in a random geographical target;

2) Human consciousness, embodied in operators, percipients, and agents, acting under some intention, volition, or desire;

3) Information, coded in binary form, being added to, or extracted from, the random physical system;

4) A resonance, or bond, or sharing of identity between operator and machine, percipient and agent, percipient and target, or two operators, that seems to facilitate the information transfer between the consciousness and the random system.

To encompass these, our particular strategy has been to appropriate the one form of existing physical theory that specifically acknowledges human observation, albeit obliquely, namely the so-called "Copenhagen" interpretation of quantum mechanics, and to stretch its concepts and formalisms to include consciousness much more broadly and explicitly. We thereby attempt to extend what has been termed the "physics of observation" into a "physics of experience." In somewhat more detail, our model is based upon three fundamental premises that might be termed 1) the geometry of reality; 2) the wave/particle duality of consciousness; and 3) the quantum mechanics of experience. The first of these suggests, in contrast to the prevailing view of an objective physical world progressing independently of the consciousness of the observer, that reality is constituted only by the mutual interpenetration of consciousness with its environment, and that it is inappropriate and unproductive to attempt representation of either in isolation. This interpenetration entails, indeed manifests itself as, a flow of information in both directions. That is, consciousness may insert information into its environment as well as extract information from it. It thus follows that *any* physical theory can only aspire to represent and predict the *experiences* of consciousness, as well as those of the environment, in the interactions of one with the other. In this view, such common physical concepts as mass, momentum, and energy; electric charge and magnetic field; frequency and wavelength; the quantum and the wave function; and even distance and time, become no more than useful information-organizing categories developed by human consciousness, and adopted by consensus, to help it correlate its experiences. As such, these concepts must reflect the characteristics of consciousness at least as much as those of any abstract physical environment. Conversely, it follows that some array of impressionistic descriptors of subjective experience must, in some form, be requisite ingredients of any truly general theory of reality, including physical reality.

We should perhaps define our use of the terms "consciousness" and "environment" in this context. The former is intended to subsume all categories of subjective experience, including perception, cognition, intuition, instinct, and emotion, at all levels, including those commonly termed "conscious", "subconscious", "superconscious", or "unconscious", without presumption of any specific psychological or physiological mechanisms. The latter includes all properties, circumstances, and influences that the consciousness *perceives* to be objectively separate from itself including, as appropriate, its physical habitat, as well as all intangible psychological, social, and historical influences that impinge upon it. In this sense, the interpenetration of consciousness and environment corresponds to the "I/Not I" dialogue of classical philosophy, and is necessarily a subjective and situation-specific process. For example, for some purposes, particularly including those involving personal health, the human physiological corpus might be regarded as an important component of the "environment" in which the consciousness functions. It is also important to recognize that this model regards the distinction between the subjective and the objective dimensions of experience as itself a construction of consciousness, deployed as a "bookkeeping" strategy to aid it in organizing the bombardment of sensory stimuli impinging upon it from what William James poetically termed "the aboriginal, sensible, muchness" (James, 1911).

Within this participatory paradigm, it is then possible to adapt, via metaphor, any physical formalism, or indeed any other existing informational schema, to represent the dynamics of the consciousness/environment dialogue. The formalisms of quantum mechanics, because of the extent to which they intrinsically acknowledge the participation of consciousness in the establishment of physical reality, and in view of their own array of "anomalous" predictions at variance with classical expectation, are a particularly useful genre of such potential metaphors. As just one example, we might invoke the quantum mechanical paradox of "wave/particle duality", which actually traces back to the philosophical debates of the earliest Greek scholars and even today finds only tentative resolution in the uncomfortable concession that under certain circumstances light and matter may behave like discrete particles, and under others, like waves. Within the postulates of the model, our interpretation of this irreducible complementarity is that it is not the physical world *per se* that imposes such dichotomy; rather, it is the sensing consciousness, or yet more precisely, it is an essential characteristic of the process of interpenetration of consciousness and its physical environment.

If this concept is valid, then it is also consistent to attribute to consciousness itself the option of wave-like as well as particulate character. In other words, the consciousness that has conceived both particles and waves, and found it necessary to alternate them in some complementary fashion for representation of its physical environment, may find a similar complementarity useful in representing itself. The prevailing conceptualization of consciousness, particularly in contemporary Western culture, is basically "particulate" in nature. That is, consciousness is usually regarded as well localized in physical space and time and capable of "collisional" interactions with only a few aspects of its environment and with a few other similarly localized consciousnesses at any point in its experience. But if consciousness were to allow itself the same wave/particle duality that it has already conceded to numerous physical processes, it would have at its disposal a host of wave mechanical capacities, such as remote influence, interference, diffraction, barrier penetration, and resonance, that could accommodate anomalies like those encountered in the experiments described above, as well as many other dimensions of human experience that currently fall outside the scientific purview. More specifically, just as the information and energy carried by physical wave processes may be widely diffused over broad regions of space and time, rather than sharply localized in well-defined geometrical regions, so may our "consciousness waves". Unlike particulate phenomena, intersecting waves may pass through one another with no permanent distortion, yet during that intersection complex superposition or interference patterns may be formed. The ability of waves reaching an interface or discontinuity in the surrounding medium to reflect some portion of their amplitude and transmit another portion, also differs sharply from the behavior of their particulate counterparts, as does the phenomenon of so-called "evanescent" waves whose influence can penetrate for some distance into regions inaccessible to discrete particles. And perhaps most importantly, wave systems may establish resonances with one another, and with their environmental confines, that manifest as tangible standing oscillations. All of these capabilities transpose nicely into representations of anomalous consciousness effects.

Lest this metaphorical adaptation of physical formalism appear unreasonably extreme, it should be recalled that quantum wave mechanics itself has borrowed generously from the concepts of classical physics to describe metaphorically the phenomena of the microphysical world, most notably in its atomic and molecular "orbital" theories and its treatments of atomic "collisions". The Copenhagen interpretation of Bohr and his colleagues attributes the amplitude of atomic "matter waves" to be indicative of the probability of observing a particular particle, in a particular state, at a particular position and time, when an appropriate experiment to measure these properties is actually implemented. Hence, this wave mechanics of matter does not describe physical behavior-in-itself; it only describes the *observation* of physical behavior. From this, it is not so large a reach to generalize the concept of "observation" to encompass the full spectrum of the information processing capacities of consciousness, and instead of speaking of "probability-of-observation" waves, to postulate "probability-of-experience" waves.

This broadening of perspective is actually quite consistent with the position taken by many of the patriarchs of quantum mechanics themselves. In the words of Werner Heisenberg, for example:

> "... in the Copenhagen interpretation of quantum theory we can indeed proceed without mentioning ourselves as individuals, but we cannot disregard the fact that natural science is formed by man. Natural science does not simply describe and explain nature; it is a part of the interplay between nature and ourselves; it describes nature as exposed to our method of questioning. This was a possibility Descartes could not have thought, but it makes the sharp separation between the world and the I impossible."
> (Heisenberg, 1976)

Beyond the various departures from classical particle behavior implicit in its wave-mechanical approach, quantum physics imposes a number of other empirical postulates that can also be appropriated as useful metaphors for representing the information acquisition, delivery, and processing capabilities of consciousness. These include the principles of correspondence, exclusion, indistinguishability and, perhaps most importantly, complementarity, with its associated principle of uncertainty. Collective adaptation of these tenets, along with the quantum mathematical formalisms, constitutes a "quantum mechanics of consciousness" that can provide a variety of conceptualizations and vocabulary for discussion of the interpenetration of consciousness and its environment. Many aspects and examples of this approach are detailed in numerous references (Dunne and Jahn, 1989a,b; Jahn, 1991; Jahn and Dunne, 1983a, 1986, 1987, 1994); here we shall outline just two: the "atomic" and "molecular" structures of consciousness.

If consciousness is afforded a wave mechanical nature, subject to the principles of quantum mechanics, its palpable experiences should be associated with the standing wave patterns, or "eigenfunctions", it achieves in its prevailing environment. In physical quantum mechanics, the environments are usually represented as potential profiles in which the wave systems are constrained. In the consciousness metaphor, the broader environments, as defined above, may be similarly conceptualized, albeit in terms of more complex and abstract profiles of more subjective properties. Within such profiles, the consciousness manifests its experience via a discrete set of similarly subjective standing waves, characterized by observable values of the pertinent experiential properties.

With these "consciousness atoms" thus defined, their combination into "consciousness molecules" may also be undertaken. This bonding process, which is classically inexplicable even in physical situations, is a particularly illuminating format for representation of the operator/machine and percipient/target anomalies described earlier, and for broader comprehen-sion of many other consciousness-related phenomena as well. In the physical regime, when the wave patterns of the valence electrons of two atoms come into close interaction, they cannot be distinguished in any pragmatic sense, and this loss of identity or information, when properly acknowledged in the quantum mechanical formalism, leads to an "exchange energy" which is the basis of the molecular bond. The strength of this bond depends on the spin orientations of the two interacting electrons, as well as on the pattern of overlap of the two electronic wave functions within the composite potential well established by the two atomic nuclei and the electrons themselves. (This process is an excellent example of the equivalence of energy and information mentioned earlier.)

Our metaphor would thus predict that an individual consciousness immersed in a given environmental situation would establish a set of characteristic experience eigenfunctions. A second individual, exposed to the same situation, would manifest a different set of experiences. However, if these two consciousnesses were strongly interacting, their experiential wave functions would become resonantly intertwined, resulting in a new pattern of standing waves in their common environment. As demonstrated in the co-operator experiments described earlier, these "molecular" experiences may be quite different from the simple sum of their "atomic" behaviors, and if we insist on comparing them with such, they will appear anomalous. In their own properly constituted molecular context, however, they are quite normal. The importance of gender pairing in these experiments also suggests an analogy to the spin pairing in the physical bonds.

Even our individual operator/machine effects may be addressed in this fashion if we are willing to concede some form of "consciousness" to the machine, in the sense that it, too, is a system capable of exchanging information with its environment. Thus, a bonded opera-tor/machine system should not be expected to conform to the isolated operator and isolated machine behaviors, but to establish its own characteristic behavior. Viewed as an influence of one system (the operator) upon another (the REG), the empirical results are inexplicable within the canonical behaviors of the isolated systems; viewed as a process of wave-mechanical resonance between two components of a single interactive system, they behave quite appropriately. Otherwise put, the surrender of *subjective* identity implicit in the human/machine bond is manifested in the appearance of *objective* information on the digital output string. Its entropy has literally been reduced by its involvement with a human consciousness.

Such a model can also be applied to the remote perception effects in terms of a resonant bond between the percipient and the agent that enables the "anomalous" acquisition of information about the prevailing physical target environment in which both are emotionally immersed. Alternatively, one might pose the "molecular bond" between the percipient and the target scene, with the agent assigned the role of establishing a facilitating environment for the anomalous communication between the two. In either representation, the merging of *subjective* identities again enables the transfer of *objective* information, in this case manifesting as a coherence between the agent and percipient responses.

This concept of resonance as a mechanism for introducing order into random physical processes may also be a viable model for comprehending various other equally "anomalous", if somewhat less provocative, processes, such as human creativity, whether artistic, intellectual, or biological, or human trust, hope, or affection. The essential mechanisms of some of these may in fact devolve from the same principle of indistinguishability, wherein the surrender of information distinguishing the two interacting subsystems within a single complex system translates into an increment in the structural strength of the bonded system. Thus, when the perceived boundary between consciousness and its environment is eliminated or reduced via subjective merging of the "I" with the "Not I", the resultant bonded system may marginally alter both the physical structure of the environment and the experience of the consciousness in some consequential way. If this resonance entails a volitional or intentional component, be it conscious or unconscious, the bonded system will reflect that intention in a manner unique to the particular "molecule." Our experimental results suggest that while the scales of these effects are marginally small and impossible to identify on a trial-by-trial basis, they nevertheless can manifest in significant probabilistic trends accumulated over large bodies of experience.

From all of this emerges the intriguing possibility that what we denote as "chance" behavior, in any context, rather than deriving from some ultimately predictable, fully mechanistic behavior of a deterministic physical world, is actually some immense subsumption of a broad distribution of potentialities reflective of all possible resonances and intentions of consciousness with respect to the system or process in question. Sir Arthur Eddington proposed the possibility in only slightly different terms:

> "It seems that we must attribute to the mind power not only to decide the behaviour of atoms individually but to affect systematically large groups - in fact to tamper with the odds on atomic behaviour. ... Unless it belies its name, probability can be modified in ways in which ordinary physical entities would not admit of. There can be no unique probability attached to any event or behaviour; we can only speak of `probability in the light of certain given information,' and the probability alters according to the extent of the information." (Eddington, 1978)

Or, in the more poetic words of Schiller's Wallenstein:

> "There is no such thing as chance, and what we regard as blind circumstance actually stems from the deepest source of all." (Schiller, 1952)

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