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Series Position Effects In Random Event Generator Experiments

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with an Appendix:

"Serial Position Effects in the Psychological Literature"

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Abstract — Effect sizes achieved by human operators in random event generator anomalies experiments show correlations with the ordinal positions of the experimental series in both the collective and individual databases. Specifically, there are statistically significant tendencies 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. Such correlations appear in both local and remote experiments, and are also indicated over a sequence of different experimental protocols, but no similar effects are found in baseline or calibration data. These serial position patterns thus appear to be primarily psychological in origin, and may subsume the rudimentary "decline," "primacy," "recency," and "terminal" effects propounded in the parapsychological and psychological literature. The results also emphasize the importance of very large individual databases in determining the asymptotic effect sizes in any given experiment of this type.

Introduction

Casual retrospective examinations of the huge random event generator (REG) databases acquired over fourteen years of experimentation in this laboratory (Nelson & Dobyns, 1991) have suggested that certain subtle patterns of operator performance associated with the degree of experience with given devices and/or protocols may reside therein. For example, the largest coherent subset of REG data, acquired using single operators proximate to a machine driven by a microelectronic diode noise source, displays a statistical pattern of scores that correlate with the ordinal position of the experimental series in the operator data sets. More specifically, it appears that early success in the first series is substantially decreased in the next series or two, and then recovers over the next few series, at least partially, to comparatively stable success levels.

These impressions are reminiscent of various allusions to "decline effects," "position effects," or "learning effects" in the parapsychological literature, and to observations reported in the broader psychological domains of learning, memory, attention, and vigilance (cf Appendix). For example, Rhine and Humphrey describe temporal effects in ESP experiments wherein the scoring is more extreme at the ends of runs than in the middle, leading to U-shaped score patterns (Rhine & Humphrey, 1944). Rhine later refers to "patterns of bit frequency that relate to the structure of the test," and notes that adults display such patterns more markedly than children; that the effects are more pronounced in experiments where operators work without an observer and where they are aware of their progress as the test progresses; and that these trends may be observed from the level of the trial up to that of the full experiment (Rhine, 1969).

In the hope of clarifying such serial position effects, we have undertaken a more detailed and quantitative analysis of possible correlations of REG scores with series order. The single operator, local, diode database employed for this purpose comprises some 2.5 million total trials arrayed in 522 experimental series of varying sizes, generated by 91 individual operators. Since details of these experiments have been reported elsewhere (Nelson & Dobyns, 1991; Nelson, Dunne, & Jahn, 1984; Jahn, Dunne, & Nelson, 1987; Jahn & Dunne, 1987; Nelson, Bradish, & Dobyns, 1989; Jahn, Dobyns, & Dunne, 1991; Dunne & Jahn, 1993), here we will simply summarize the pertinent terms and conditions. A tripolar protocol requires operators to intersperse efforts to produce counts higher or lower than the theoretical expectation, with baselines where the machine is operated without any explicit intention. A trial consists of 200 random binary digits, typically generated at 1000 per second, which are compared with a regularly alternating + - + - . . . sequence. The number of conforming bits is displayed via LEDs on the face of the device, and automatically and redundantly recorded in a computerized data management system. Trials are generated in runs of 50, 100, or 1000, depending on operator preference or protocol constraint. In most cases, the trials are automatically sequenced after a single button press, although they may also be produced in a manual mode where each trial is independently initiated. An experimental series, which is the basic statistical unit of these experiments, constitutes an independent experiment of a predetermined number of trials generated under each of the three intentions of "high," "low," "baseline" with all other conditions held constant. In one protocol ("volitional"), the intended directions are selected by the operator, with a constraint on balance, prior to the trials. In an alternative protocol ("instructed"), the intended directions are imposed by a random indicator. Data are produced in sessions, typically about one hour in duration, consisting of anywhere from a minimum of five 50-trial runs to one or more entire series, again depending on operator preference or protocol structure. All of the operators are anonymous, uncompensated, adult volunteers, none of whom claim extraordinary abilities. No training or incentives are provided, and individual styles vary widely from very casual to highly intense. No attempts are made to correlate performance with any psychological or physiological parameters, other than those implicit in the protocol variations.

The database under study includes series of 5000, 3000,2500, and 1000 trials per intention and combines the results of three distinct experiments, which differ in terms of run length, series size, and a number of other optional secondary parameters. However, all follow the same tri-polar protocol and address the same primary correlate — the pre-recorded intention of the operator to shift the means of the output distributions in a given direction. All are conducted under tightly controlled conditions, with the data redundantly recorded on-line in appropriately labeled computer files and on a paper tape printout. The operators are in the same room as the device during its operation, and receive visual feedback during the course of each series, as well as summary statistical feedback at its conclusion. Thus, for purposes of analysis, as well as for the operator's conceptual perspective, each series can be regarded as an independent replication of the basic experiment, standing as a complete unit of effort in its own right.

Database

The average mean shifts of the approximately 840,000 trials per intention compounded in this data set are statistically significant in both the high and low directions. The high efforts produce an overall mean count of 100.026 (z = 3.369, $p = 4 \times 10^{-4}$), and the low efforts a mean of 99.984 (z =-2.016, p = .022). The probability of obtaining this separation of means of .042 between the two directions of effort over a database of this size by chance is less than 7×10^{-5} (z = 3.809). In contrast, the overall baseline mean of 100.013 is not statistically different from the expected value of 100.000 (p = .096 two-tailed). Since extensive machine calibrations confirm that the undisturbed behavior of the device conforms well to theoretical chance expectations, with no indications of secular trends (Nelson, Bradish, & Dobyns, 1989), all comparisons in this paper are made against theoretical predictions.

An unavoidable variable that must be carried through this serial position assessment is the number of series performed by each of the 91 participating operators which, for reasons of interest or availability, ranges from one to sixty-five. It should be noted, however, that the individual operator effect sizes, irrespective of their database sizes, distribute about the shifted means largely as one would expect by chance, with no indication beyond random fluctuation that any operators are more "effective" than the others (Dunne, et al, 1988). For purposes of analysis the entire database has been divided into just five subsets, namely the compounds of all first, all second, all third, and all fourth series, and all series numbered five and higher, henceforth denoted by “5+”, as summarized in Table 1. Note that although the last subset was produced by only 21 "prolific" operators, it constitutes 280 series or 54% of the total database. It is thus possible to construct a more balanced set of data consisting of the (1, 2, 3, 4, 5+) series results of these prolific operators alone, for our first attempt to assess any possible series order effects.

TABLE 1
Distribution of Operators over Series Number

Series *No.*		***No. of Operators*** (%)
1		91 (100%)
2		68 (75%)
3		58 (64%)
4		25 (27%)
5	5+	21 (23%)
6	5+	20 (22%)
7	5+	17 (19%)
8	5+	15 (16%)
9	5+	13 (14%)
10	5+	13 (14%)
>10	5+	12 (13%)

Prolific Operator Results

Figure 1 displays the effect sizes for all the tripolar efforts of these 21 prolific operators as a function of series number 1 through 5+. The combined effect sizes of all of their data are indicated at the extreme right of the graph. Error bars are 1.65 σ ($p = .05$, one-tailed) for the high-and low-effort data, and 1.96 σ (two-tailed) for the baseline data. In the high efforts, a highly significant positive effect in the first series is followed by a sharp decline to negative values in series 2, **3,** and 4, after which the positive trend is recovered in the fifth series and beyond. The low efforts show a slightly different pattern, with first and second series effects significant in the intended direction followed by a sharp reversal to an opposite effect in the third series. The data then revert to the intended direction in the fourth series and beyond. The high-low difference in these data reflect the combined negative results of both intentions in the third series to produce a distinct reversal in the positive effects established in all the other series, where the separations between the high and low values are consistent with the operators' directions of effort. Finally, the baselines interspersed with these intentional efforts show no statistical evidence of such a pattern.

These series position patterns can be submitted to regression analysis to determine the statistical significance of the observed trends. For example, the quadratic terms of the regressions provide indications of the degree of curvature in the series sequences. Using an appropriate error term that includes measurement uncertainty for the individual points, these coefficients can then be converted to standard z-scores, noted on the graphs as *Z*2. In the high-going efforts, the one-tailed probability of the quadratic coefficient is 4×10^{-4}, attesting to a significant U-shaped trend; in the low efforts, despite the striking reversal of effect in the third series, the curvature is actually non-significant ($p = .290$). The high-low difference curvature is significant with a probability of .004, driven primarily by the high-intention results. There is no significant curvature in

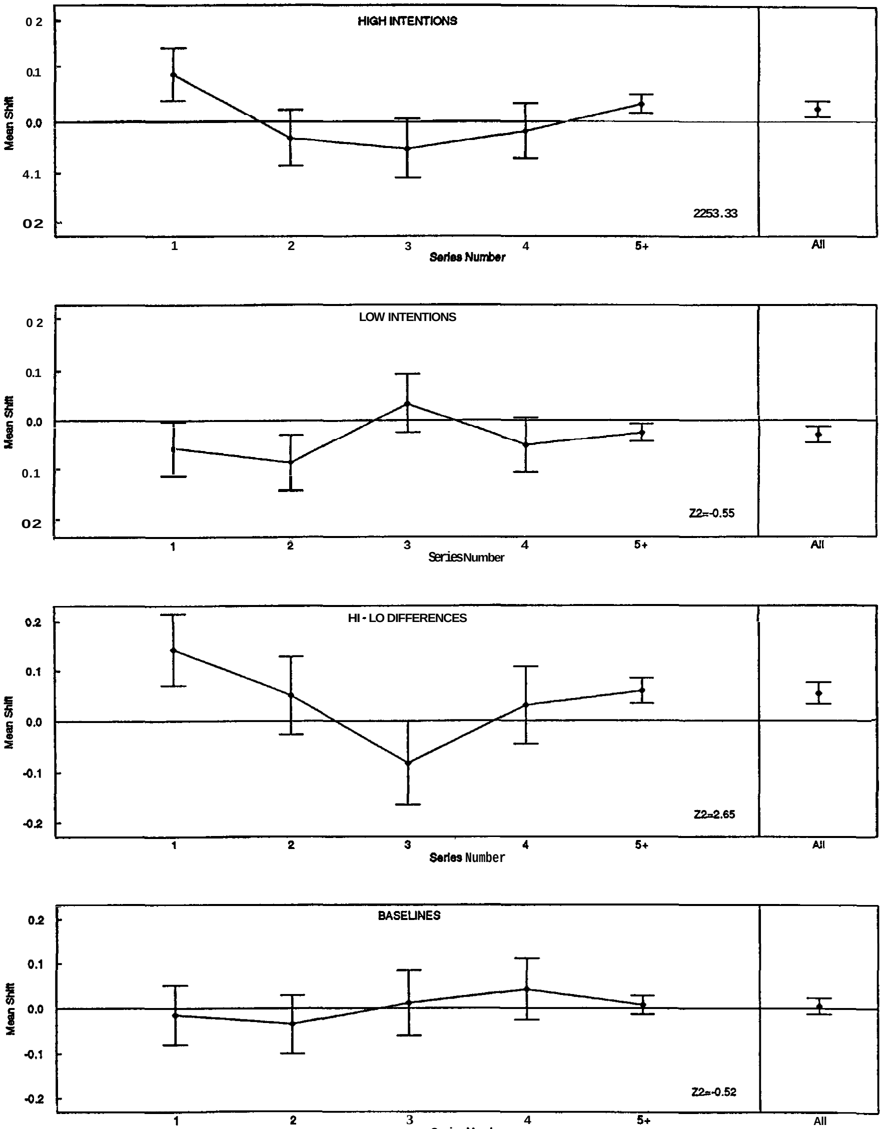

Figure 1: Effect Size By Series for 21 Prolific Operators

the baselines, at a probability of .604. (All baseline probabilities are calculated on a two-tailed basis, since excessive excursions in either direction would constitute an anomaly.)

Table 2 summarizes the effect sizes, or mean shifts, of each of these prolific operator series subsets in numerical form.

TABLE 2
REG Effect Sizes by Series Position
(364 Series, 21 Prolific Operators)

Subset	*High*	*Low*	*AHi-Lo*	*Baseline*
1st Series	0.093 *	-0.054 *	0.143 *	-0.015
2nd Series	-0.032	-0.083 *	0.051 *	-0.035
3rd Series	-0.053	0.034	-0.083	0.012
4th Series	-0.018	-0.049 *	0.031	0.043
5th Series +	0.035 *	-0.024 *	0.059 *	0.008
All	0.025 *	-0.029 *	0.054 *	0.005

"Significant in direction of effort at $p < .05$

Full Database Results

Although the prolific-operator subset provides the most balanced basis for assessing series order patterns, it is instructive to compare those results with those of the full database to assess whether the observed trends can be generalized across unbalanced data cells. Table 3 and Figure 2 present such results for all 522 series comprising the total REG local diode database, again by series order. Despite the fact that the individual contributions from each of the 91 operators are quite disparate in terms of the number of series in each subset (cf Table 1), the patterns remain generally similar to those shown above. There is a more rapid recovery of the effect size in the high efforts, and the third series reversal is even more marked in the low efforts than in the prolific operator subset, but the overall trends, like those of the high-low differences, are essentially the same. As before, the baselines show no evidence of a series order effect. Regression analysis once again yields significant coefficients in the quadratic components of the high efforts ($p = .019$) and the high-low differences ($p = .016$), while the low efforts remain non-significant ($p = .154$), as do the baselines ($p = .934$).

The graphs of Figures 3 and 4 present the preceding prolific operator and total database serial position effects in another instructive format, namely as progressions of the ***cumulative*** means. In essence, these displays respond to

TABLE 3
REG Effect Sizes by Series Position
All Local Data (522 Series, 91 Operators)

Subset	*High*	**Low**	*AHi-Lo*	*Baseline*
1st Series	0.046 *	-0.009	0.055 *	0.025
2nd Series-0.019	-0.033 *	0.015	0.006	
3rd Series	0.018	0.046	-0.026	0.025
4th Series	0.000	-0.033 *	0.033	0.026
5th Series +	0.035 *	-0.024 *	0.059 *	0.008
All	0.026 *	-0.016 *	0.042 *	0.013

* Significant in direction of effort at $p < .05$

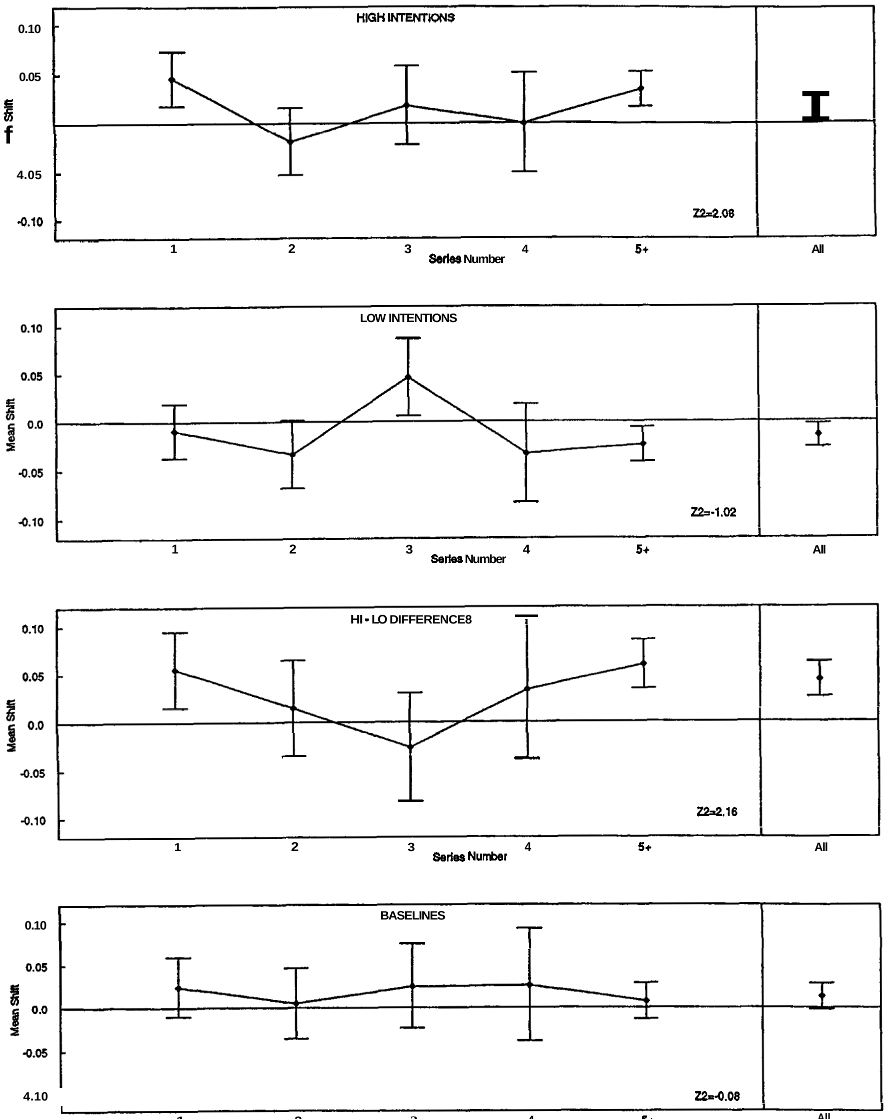

Figure 2: Effect Size By Series for All Operators

the important question: "If the experiment had been terminated at the end of the nth series (n = 1, 2, 3 . . .), what would have been the accumulated effect size?" The salient information here is the *rate* at which these cumulative means converge to stable asymptotic values, and the indication is somewhat ambivalent. On the one hand, some four to five series suffice to subsume most of the pathological variations of the early series means into relatively stable

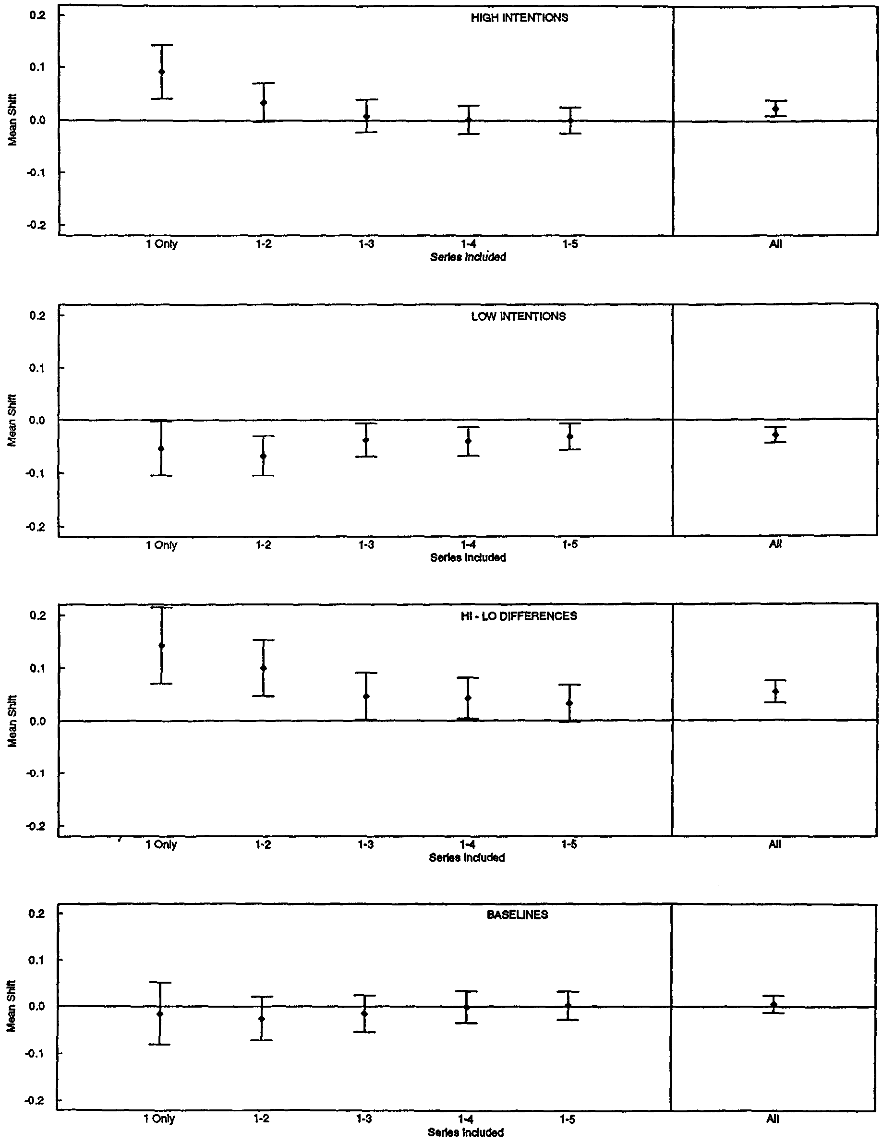

Figure 3: Cumulative Effect Size By Series for 21 Prolific Operators

values, but even these differ somewhat from those ultimately achieved after yet many more series are included. These latter, slower progressions in the cumulative means to significant terminal values are largely attributable to a few extremely prolific operators whose effect sizes persist through many tens of series (Dunne, Dobyns, & Jahn, 1993).

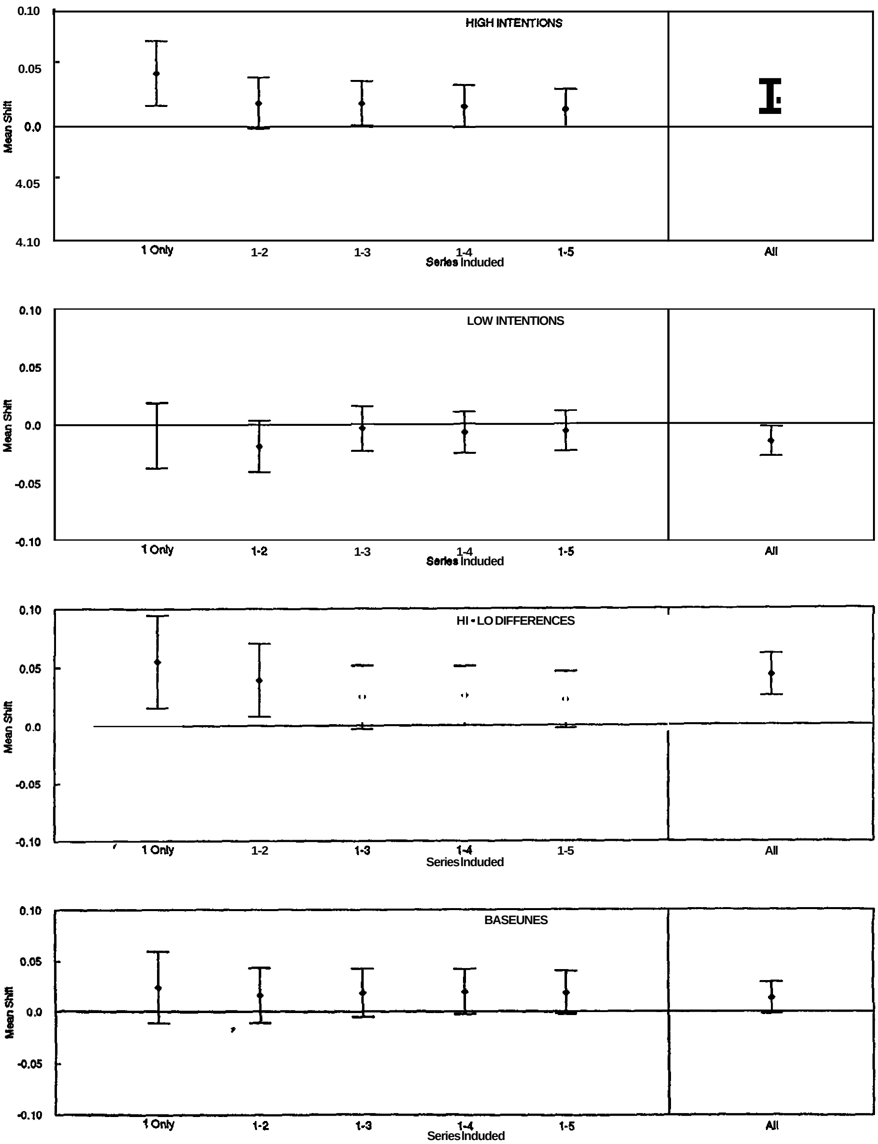

Figure 4: Cumulative Effect Size By Series for All Operators

Operator-Specific Patterns

Throughout the entire laboratory program, most especially the REG class of experiments, the need to retain complementary perspectives between global results averaged across large pools of operators, and operator-specific results

TABLE 4
REG Effect Sizes By Experiment

Experiment	*No Trials* ***per*** *Intention*	*High*	*Low*	*AHi-Lo*	*Baseline*
OldREG	–300,000	.035 *	-.019	.054 *	.007
REMREG	177,000	.005	.001	.004	.018
ThouREG	360,000	.028 *	-.020 *	.048 *	.016
All	837,000	.026 *	-.016 *	.042 *	.013

* Significant in direction of effort at $p < .05$

that reveal individual characteristics, has been evident. This complementarity is equally important in these serial position studies. So far we have displayed the global results of two groups of operators, and have extracted therefrom the statistical characteristics of those representative groups. Next we turn to individual operator data to assess the degree of variability embodied there that is being subsumed in the global results. For this purpose, the individual operator serial position patterns, per se, are difficult to interpret, given the large error bars that unavoidably attend the relatively small sample sizes for each series mean data point. However, the cumulative mean representations are much better behaved and show clear similarities to the global results in the same format. In fact, to good statistical generality, each of the individual operators is found to contribute marginally but systematically to the global serial position patterns, with few if any stark aberrations therefrom. In other words, as is the case for overall effect sizes, the global serial position effects appear to be generic, rather than accidental combinations of widely varying individual performances. It thus seems reasonable to expect that similar global effects would be displayed by totally different operator pools. (Cumulative effect size graphs for each of the 21 prolific operators are assembled in Dunne, Dobyns, & Jahn (1993), Appendix A.)

Protocol Dependence

As mentioned earlier, the local REG database is itself a composite of three distinct eras of experimentation. While the basic tripolar protocol remained constant throughout, three major variations were explored over the program's eleven-year history, involving manipulation of certain secondary experimental parameters, most notably run length and series size (Nelson & Dobyns, 1991). The first era of investigation, termed OLDREG, consisted of 103 series, most of which required 2500 trials per intention, although 18 of the earliest series consisted of 5000 trials per intention, all generated in runs of 50 trials each. The second era, termed REMREG, consisted of 59 series of 3000 trials per intention, generated in runs of 1000 trials each. The third era, called THOUREG, produced 360 series of 1000 trials per intention, which were generated in runs of 50, 100, or 1000 trials, depending on operator preference.

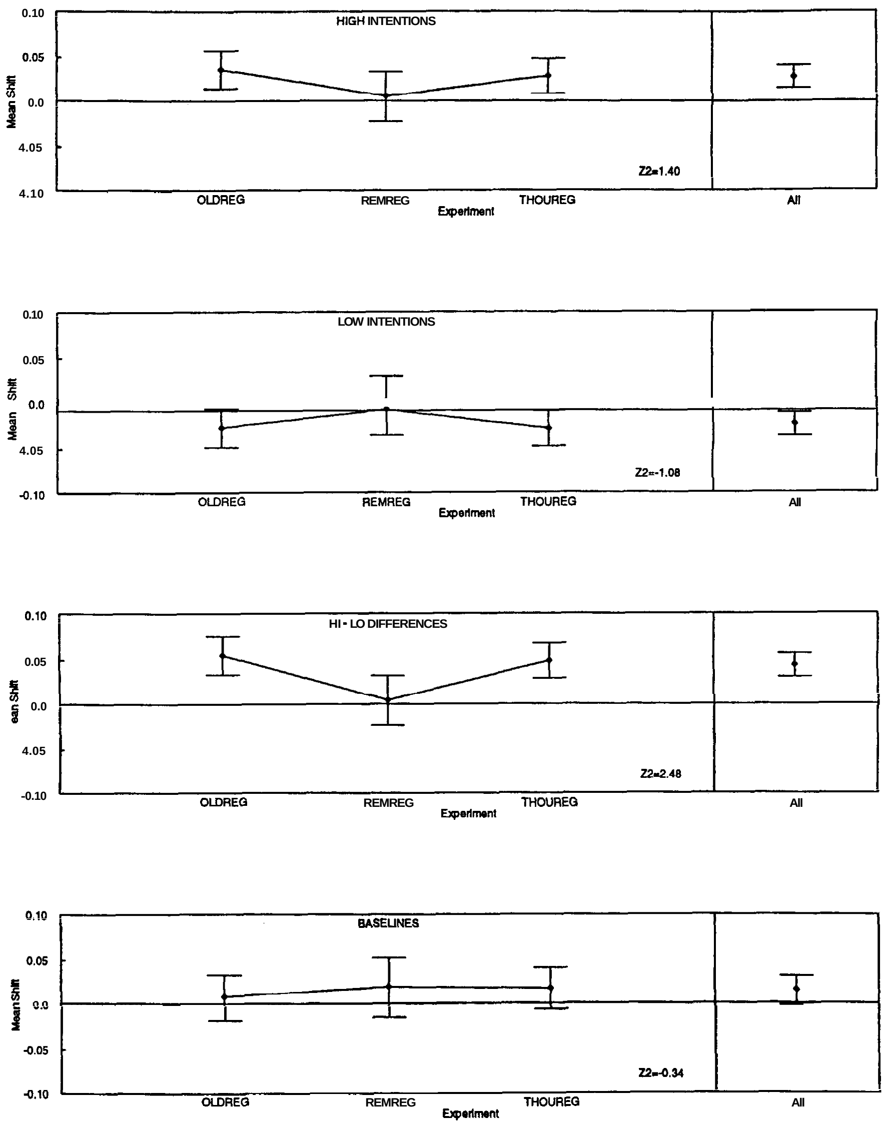

Figure 5: Effect Size By Experiment Order

Table 4 summarizes the composite effect sizes for each of these databases by intention, and Figure 5 displays these in graphic form.

The progression of final scores across these three experiments could be construed to display a pattern of initial achievement-decline-recovery somewhat similar to the series position effects described earlier. The HI-LO difference pattern has a curvature significant at $p = .014$, driven by a "High" curvature at

TABLE 5
REG Remote Database Subsets
Indicating Sequence of Operator Series

Series No.		*No. of Operators* (%)
1		27 (100%)
2		21 (78%)
3		19 (70%)
4		16 (59%)
5	+5	10 (37%)
6		9 (33%)
7		8 (30%)
8		8 (30%)
9		8 (30%)
10		8 (30%)
>10		7 (26%)

$p = .033$ and a "Low" at $p = .100$. In contrast, the baseline trend shows no evidence of curvature ($p = .922$). Although identification of trend curvatures from three-point data is risky, the possibility of "protocol-position effects" superimposed on the series position effects cannot be totally ruled out, either as a confound on the latter, or as evidence of a self-similar character of the effect, as Rhine had proposed (Rhine, 1969). Further illumination of this aspect might also follow from searches for position effects at the levels of experimental runs or even individual trials, but in its present architecture, our data management system does not allow sufficiently convenient access to this level of data structure to make such assessments feasible.

Remote REG Database

Another large database was generated on this same device under a "remote" protocol, where the operators were physically separated from the machine by considerable distances, up to several thousand miles (Dunne & Jahn, 1992). All of the remote operators had also served as local operators, and the remote protocol followed the same tri-polar structure, but experientially it certainly qualifies as a distinct experiment. For this reason, an independent examination of the remote REG database by series order was also undertaken. A total of 184 remote series, totaling 396,000 trials per intention, were produced on the diode device by 27 operators. All were generated in 1000-trial runs, initiated at prearranged times by experimenters who were blind to the sequence of operators' intentions. As in the local database, the individual operator contributions were somewhat unbalanced, with only ten operators producing five or more series. The series subsets by operator contribution are summarized in Table 5, and the effect sizes for the various intentions presented in series order in Table 6 and Figure 6.

These remote REG data show effect sizes comparable to the local data, with similar serial order trends, but only the high-low differences produce a margin-

TABLE 6
REG Effect Sizes by Series Order
All Remote Data (184 Series, 27 Operators)

Subset	*High*	*Low*	*ΔHi-Lo*	*Baseline*
1st Series	0.027	-0.013	0.040	0.004
2nd Series	-0.001	0.025	-0.026	0.041
3rd Series	0.009	0.025	-0.016	-0.000
4th Series	-0.002	-0.016	0.013	0.013
5th Series +	0.035	-0.025	0.060	0.007
All Data	0.022 *	0.001	0.032 *	0.013

* Significant at $p < .05$

ally significant quadratic term (p = .048). Both the high and low efforts show slight curvatures in the same directions as the local data (p = .139 and p = .105, respectively), and the baselines show none at all (p = .730). It is perhaps noteworthy that the recovery levels in the 5^+ subset are actually somewhat larger than the first series values, in some contrast to the local patterns where the recovery is less complete. The fact that the remote operators had had prior experience in the local protocol may possibly confound these results somewhat, but their general consistency with the local values nevertheless reinforces both bodies of evidence.

Summary

Like so much of the empirical data acquired in research on consciousness-related anomalies, the persistent patterns of serial decline and recovery displayed in the REG databases, both local and remote, are too prominent to be ignored, yet too enigmatic and complex to support any obvious simple interpretation. Since no such patterns appear in any of the baseline data or machine calibrations, it can be reasonably assumed that these trends reflect some characteristic of the operators, rather than some artifact of machine performance, and thus they could conceivably provide some insight into the psychological dimension of these human/machine interactions. This laboratory has traditionally eschewed any assessments of psychological or physiological characteristics of its operators, for a number of reasons. This, along with the statistical nature of the data and the lack of any systematic record of the operators' subjective responses to the series order parameter thus precludes pursuit of specific psychological correlates at this time. However, there is an extensive literature on serial position effects associated with learning, memory, and other psychological/cognitive processes, as well as repeated reference to this phenomenon in parapsychological publications, some of which is summarized in the following Appendix. The broad similarities of the patterns in our data to those reported therein suggest that some fundamental attribute of the human psyche may be involved in all of these.

One other intriguing, if highly speculative, analogy can be found in a totally different sector, namely the ubiquitous patterns of damped periodic oscilla-

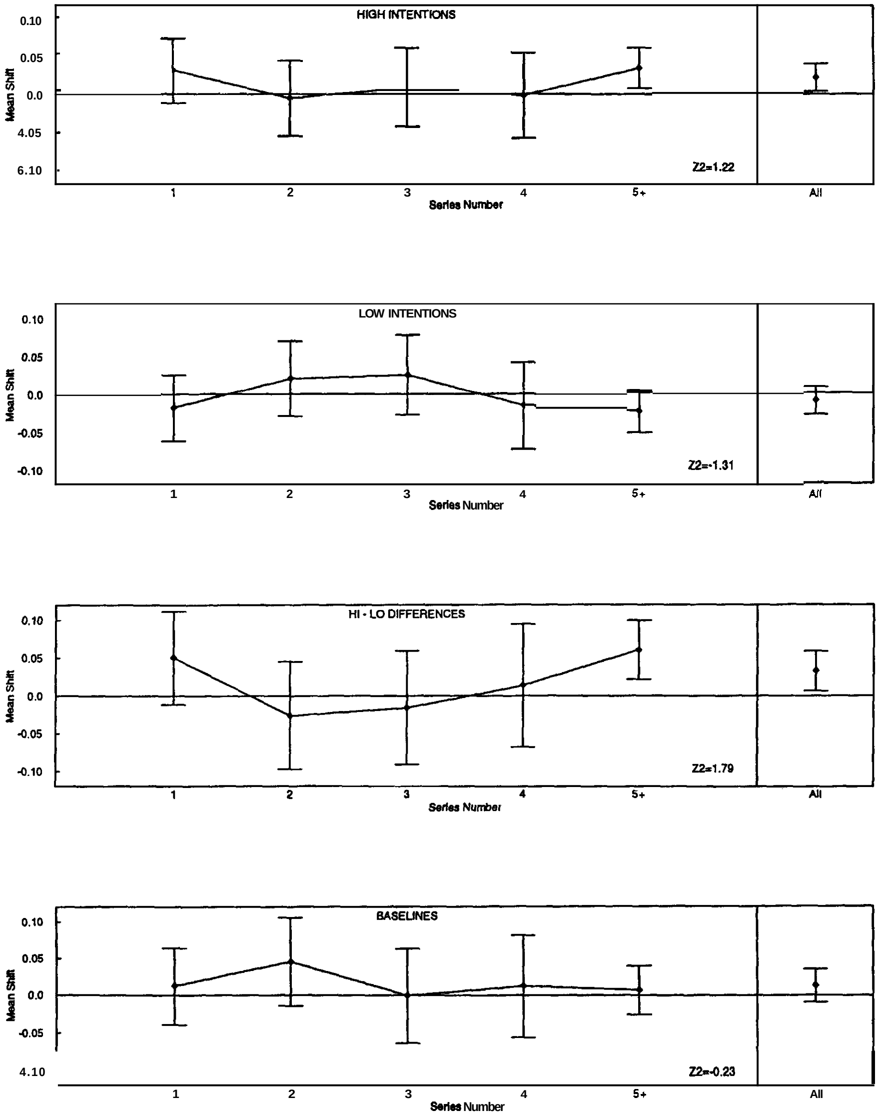

Figure 6: Effect Size By Series In Remote Data

tions found in a host of mechanical and electromagnetic physical systems, in numerous forms of free wave propagations, and in various biological functions. All of these feature an initial maximum signal excursion, followed successively by a reverse phase, a lesser recovery to the initial polarity, and eventual stabilization at some steady-state value. The well-known requisites for such behavior are an initial impulse or perturbation, a restoring force, a natural resonant frequency, and a dissipative component or damping agent. Further scrutiny of experiments such as those reported here might lead to identification of psychological analogues of these physical variables, thereby enabling progress toward a more quantitative science of the psyche and its role in the physical world.

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Appendix
Serial Position Effects in the Psychological Literature

ANGELA THOMPSON

Many of the earliest accounts of serial position effects occur in published works devoted to memory and learning (Crowder, 1976; Hunter, 1976). In the late 1800's, Ebbinghaus found that word lists were learned and remembered serially, and that the position of the words in the list contributed to their level of recall (Hunter, 1976):

> As the person proceeds from one memorizing trial to the next, certain items in the list are learned more rapidly than others. The items which are memorized soonest are those which occur at the beginning of the list, and the items which are memorized slowest are those in the middle. In other words, the readiness with which any item is memorized depends not only on the item itself but also on the position it occupies in the list as a whole: whether it comes near the start of the list, or the middle, to the end. This is known as the 'serial-position effect'. (p. 135)

Crowder felt that seriality was one of the properties of thought itself, and points out the orderliness of sequential thought as an explanation for the effect. Commenting on the work of Koriat and Fischhoff (1972), who thought that serial effects had their origins in semantic memory, Crowder (1976) concluded:

> We have seen serial-position effects extending all the way from the most transient measures of episodic memory to the most well-learned knowledge people carry around with them. (p. 460)

He proposed two possible contributory effects to such tendencies: the primacy and recency effects:

> In just about any learning task in which the ordering of items is required, and in many where it is not, there is better performance at the beginning and end of the series than elsewhere, with the hardest position occurring somewhere just beyond the middle. The advantage of the early items is called the primacy effect and the advantage of the last items is called the recency effect. (p. 445)

but then went on to admit that whether these primacy and recency effects are linked by a single causative factor still needed to be determined:

> . . . . the theoretical analysis of the serial-position effect in a state of untidiness that is almost embarrassing in view of the extreme reliability and pervasiveness of the phenomenon. (p. 477)

More recent research has been conducted in spatial memory tasks of preverbal children (Cornell & Bergstrom, 1983) and adult human memory research (Proctor & Healy, 1987; Ley & Long, 1988; Auday, Sullivan, & Cross, 1988; Penney & Blackwood, 1989; Jahnke, Davis, & Bower, 1989; Wagner & Pfautz, 1978; Kresner, Measom, & Forsman, 1984). These effects have even been noted in non-human animal studies of spatial memory (Jahnke, Davis, & Bower, 1989; Wagner & Pfautz, 1978; Kresner, Measom, & Forsman, 1984; Santiago & Wright, 1984; Wright, Santiago, & Sands, 1984; Wright, 1985;

Dale, 1987). Serial-position effects have also been employed as a means of investigating and improving learning skills in handicapped students (Glidden, Pawlewski, Mar, & Zigman, 1979; Laufenberg & Scruggs, 1986), with deaf students (Bonvillian, 1983; Krakow & Hanson, 1985), and with disabled readers (Manis & Morrison, 1982). Declines in the production of serial-position effects have been noted in memory tasks performed by Alzheimer patients (Pepin & Eslinger, 1989), in patients with brain damage caused by solvent intoxication (Laufenberg & Scruggs, 1986; Stollery & Flindt, 1988), and in patients with surgery to the right hippocampal region of the brain (Jones-Gotman, 1986). Serial position effects have also been generally employed as a clinical diagnostic test of memory function (Frith, 1984; Dinges & Whitehouse, 1985).

Burdick and Kelly noted a similar class of non-random occurrences in the statistical distributions of scoring in parapsychological experiments, which they termed linear and quadratic trends (Burdick & Kelly, 1977). The latter describe the tendency for scoring to be more extreme at the ends of the runs than in the middle (terminal salience), leading to U-shaped or inverted-U-shaped distributions or scoring. The authors recommended analysis of variance as an effective tool to examine these types of trends in statistical data. They noted that systematic cyclical or periodic trends may also merit attention, suggesting that techniques of autocorrelation be used to extract any evidence of such periodicity in the scoring.

Rhine and Humphrey, reporting retrospectively on data accumulated at the Duke University Parapsychology Laboratory, discovered an unequal distribution of effects which followed a typical temporal pattern (Rhine & Humphrey, 1944). They described trends similar to quadratic and serial-position effects, which they termed quarter-decline effects. In a later paper, Rhine noted some of the characteristics of these position effects, defining them as patterns of hit frequency that relate to the structure of the test, and noted that declines and U-curves were patterns most frequently observed (Rhine, 1969). These seemed more markedly demonstrated by adults than by children, and could be found from the trial level up to the experimental level.

Rhine also observed that the stricter the experimental controls, the more pronounced were the position effects, being most prevalent in experiments where a) single subjects worked alone and were aware of their progress as they recorded their own results, or b) two people worked together, alternating roles as subject and recorder. Persistence of effort through long series seemed to emphasize the phenomenon, and close preoccupation with the record sheet to intensify the effect. Position effects were found both in ESP and PK experiments, and were thought to be related to the subject's reaction to the structure of the test record. For example, spontaneity was suggested as one relevant factor. A subject's first run, where his or her expectations for an outcome would be most ambiguous, might be most conducive to spontaneous performance. However, as the experiment continued, associative factors would take on an increasing role in modulating the subject's attitudes and expectancies through feedback. Arriving at the last trial could produce a liberating feeling, allowing sufficient spontaneity to re-emerge to elude the pattern association carried along to that point.

These observations from parapsychology research are consistent with findings in studies of vigilance and attention reported in the cognitive science literature, where declines were found to relate to expectancy and subjective probability, signal probability, instruction, and feedback. Colquhoun and Baddeley showed that expectancies established during a training session could significantly influence the course of a vigilance task in terms of score decrement (Colquhoun & Baddeley, 1964; Colquhoun & Baddeley, 1967). They found a greater decrement in hits over time for observers trained with an inappropriately high signal rate than those trained with a signal appropriate to that actually used in the task. Colquhoun suggested that a major part of the decrement observed in many vigilance studies may be due to inappropriate expectancies developed in the pretask period (Colquhoun, 1975). However, as the subject matched his expectancies with the task signal, recovery could take place. Bevan and Turner examined shift expectancies and found that a shift from a positive to a negative reinforcement, or in the converse, had a greater impact on vigilance performance than continuous or negative reinforcement (Bevan & Turner, 1965). (This point may have particular relevance to the REG experiments described in the main body of this paper, where operators receive alternating positive and negative reinforcement as the machine does its random walk over the course of a run or series.)

Serial position effects have also attracted the attention of the skeptical community, with somewhat equivocal conclusions. For example, Girden and Girden (1985) note:

In the more recent literature, declines are noted in some studies, somewhat like a passing remark, rather than the result of a statistical test. In fact, more often than not, especially with a random-number generator, it is noted that there was no decline, which is usually attributed to the trial-by-trial feedback of information. Apparently, no specific tests of declines have been recently carried out, and it is possible that interest in the decline effect may further decrease and vanish. (p. 138)

Notwithstanding this speculation, it is our view, based on the results reported in the body of this paper, that serial position effects will continue to provide important indicators regarding the psychological aspects of anomalous human/machine interactions, and should be carefully studied accordingly.

Appendix References

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