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Interim Report--Objective E, Task 9

December 1986

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MEASURING REMOTE ACTION INFLUENCE ON THE VERTICAL COMPONENT OF *DUNALIELLA* VELOCITY

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Covering the Period 1 October 1985 to 30 September 1986

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SRI Project 1291

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ABSTRACT

The College of Marine Studies, Marine Biology Laboratory, of the University of Delaware has been conducting experiments with *Dunaliella* for a number of years. The researchers there claim that individuals are able to change the velocity of single algae cells significantly. SRI International has formulated a different hypothesis to explain their putative effect, i.e., individuals initiate experimental runs at a time during which the algae will naturally swim at the required velocity. The ability of the individual to initiate data collection at the opportune moment is called Intuitive Data Sorting (IDS). This report contains a historical overview of the effort at the University Delaware and a detailed outline of a proposed test of the IDS model.

I INTRODUCTION

As part of the general program at the College of Marine Studies at the University of Delaware, Dr. C. M. Pleass developed a system to measure the swimming velocities of single-cell marine alga. Having had a long time interest in psychoenergetic studies, Dr. Pleass initiated a remote action (RA) investigation with the marine alga, *Dunaliella*, using specialized hardware. As a consequence of his early effort and his promising results, SRI International asked Dr. Pleass to conduct specific experiments to test a model of psychoenergetic functioning that we call Intuitive Data Sorting (IDS). SRI let a two-year subcontract to the University of Delaware to achieve this goal. The first year's task was to develop appropriate statistics and protocols for a formal experiment that will be conducted during the second year of the contract. This report contains the results of the first year's effort.

If we assume that a valid psychoenergetic phenomenon exists in Dr. Pleass' experiments, then there are two heuristic models that are discussed below, RA and IDS, that might describe the mechanism. (The proposed protocol will allow us to determine from the data whether this assumption is valid.)

A. Remote Action

One hypothesis proposed by Dr. Pleass is that (RA) accounts for the data. (The cells are "forced" to conform to the "intent" of the participant in the usual cause-and-effect way.) This hypothesis supposes that consciousness interacts with matter and, in particular, with living systems. As a plausibility argument included in his report to SRI, Dr. Pleass invokes one side of a controversy that suggests that physical systems (micro and macroscopic), in the absence of measurement, exist as mixtures of all their possible configurations simultaneously. Although this can be demonstrated to be true with quantum systems, two basic assumptions are required to be true to extend the idea to the *Dunaliella* cells:

- Consciousness is a contributing factor in the quantum measurement process.
- Living systems exist in "indefinite" states and thus qualify as quantum systems.

The prevailing thought in physics today is that neither of these assumptions are valid. Although there are a few respected physicists who question the role of consciousness in the physical world, virtually none of them believes that macroscopic bodies exhibit measurable quantum mechanical effects. (There are circumstances in which macroscopic bodies exhibit quantum effects--superconductivity for example, but these are very special cases.) A different hypothesis, therefore, will probably more appropriately account for the data.

B. Intuitive Data Sorting

At SRI, we have been constructing a model to explain psychoenergetic data from a different perspective. Based upon an interpretation of an experiment that we conducted in 1979,[1*] we propose that an informational process, rather than a causal one, is responsible for certain putative RA phenomena. It is beyond the scope of this report to present a detailed description of the model; rather, we will provide a broad overview.

We propose that humans can make decisions (by psychoenergetic means) to take advantage of the natural and unperturbed fluctuations of a system. In the context of the Delaware experiments, suppose that an individual is asked to "make" the *Dunaliella* swim faster. Rather than "causing" the cells to swim faster, we suggest that the participant has simply initiated the trial by anticipating when the *Dunaliella* were going to swim faster as part of their natural fluctuation in velocity. Thus, the participant has capitalized upon natural events, rather than "causing" anything to occur. We call this ability IDS.

We have been able to design the Delaware experiments in such a way as to distinguish an IDS-mediated result from a causally mediated one. By definition, causal effects, on the average, will effect the *Dunaliella* on a cell-by-cell basis. For example, they are phototropic (i.e., each cell is attracted by light). The net effect of such a causal relationship is that velocity averaged over a large number of cells will produce a very large statistical effect. Because any informational processes (i.e., IDS), by definition, do *not* perturb systems (at least classically), averaging over a large number of cells can only reduce any observed statistical effects. Therefore, if the effects that Dr. Pleass observes are causal (i.e., RA), then averaging over a large number of cells will produce a strong result. If the data are weaker as a function of cell average (but remain significant), then the effect is likely to be informational (i.e., IDS).

Dr. Pleass' FY 1986 progress report is contained in Appendix A. The complete details of the apparatus, analysis, protocols, and early results, provided by Dr. Pleass, can be found

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[*] References are listed at the end of this report.

in the annex to Appendix A. A brief summary of the past experimental details are provided below.

II METHOD OF APPROACH

A. Hardware

The *Dunaliella* are contained in a small test tube in a temperature-controlled, darkened room. Their velocities are measured by a standard laser Doppler technique, which is sensitive to the velocities of individual cells. The laser Doppler apparatus allows for velocity measurements to be averaged over any number of cells ranging from one to an arbitrarily large number. A typical velocity for a single cell is of the order of 20 micrometers/sec.

The data from the laser Doppler device are accumulated, displayed, and retained on an IBM PC. All participant and monitor interactions with the experimental apparatus are performed through the IBM PC.

B. Statistics

The velocity data, like those for most living systems, have a large degree of variance, for which there are a number of contributing factors, including:

- Living systems inherently exhibit a low signal to noise ratio.
- *Dunaliellae* are sensitive to environmental factors such as light and low frequency electromagnetic radiation.
- *Dunaliellae* appear to exhibit a 24-hour circadian rhythm.

The initial attempt to analyze this kind of data included a double difference technique. Each set of data involved (1) a putative RA period, during which the participant attempted to modify the swimming velocities, (2) a control period immediately thereafter, and (3) two matching periods collected when the participant was absent, i.e., pseudo-RA and pseudo-control, respectively. The total run score by this technique is given by

$$\text{Run Score} = \sum_{j=1}^{n} (\bar{X}_j^{\text{control}} - \bar{X}_j^{\text{RA}}) - \sum_{j=1}^{n} (\bar{X}_j^{\text{pseudo control}} - \bar{X}_j^{\text{pseudo-RA}}) ,$$

where the $\bar{X}$'s are the velocity averages for each data point, [j].

Although many data were collected and analyzed by this technique, the statistical method proved to be unstable; reliable probability assessments of any effects, therefore, were difficult to obtain. The current method in use at the University of Delaware is a modification of the above procedure. Run scores are accumulated for a particular participant, and the resultant distribution is fit with a Gaussian curve. Global controls are collected under conditions that emulate the experimental conditions as closely as possible (e.g., using the same phase angle in the circadian cycle, the same RA/pseudo session spacing, etc.). These data are also fit with a Gaussian curve. The statistical significance of the RA session is estimated by the ratio of the variances between the periods of effort and the periods of global control.

III RESULTS AND RECOMMENDATIONS

The subcontract with Delaware entails a two-year effort; therefore, there are no new experimental results to report as of this writing. We recommend that a number of points be considered before initiating any formal trials.

A. Protocol

Before any tests for mechanisms are warranted, it must first be demonstrated that there is some valid psychoenergetic effect. This obvious criterion affects the selection of participants, the details of the participant–monitor interaction protocol, and the statistics. We suggest that one or more pilot series be conducted, using the final protocol and statistics to aid in the selection of "good" participants.

As described in the introduction, the tests for mechanisms require a series of trials using a known causal component (e.g., a light source). We suggest that trials be conducted when a participant is attempting to modify the algal swimming velocities; these trials should be counterbalanced by identical trials during which the participant is replaced with a light source adjacent to the cells.

B. Statistics

As part of our recommendations for methods of analysis, we include a detailed description of a technique that is commonly used in geophysics and that may be applicable to the Delaware experiment.

1. Background

Radar technology has provided a number of powerful techniques to perform time series analysis upon "noisy" data similar to that described above. We will focus our attention upon a technique that is in common use in geophysics.

In 1913, C. Chree introduced a method to correlate sunspot activity with terrestrial magnetism.[2] His approach was a particularly powerful one and exists today under a number of different names (e.g., epoch analysis, and signal averaging). Signal averaging is a widely used technique in such diverse fields as brain research and radar; therefore, quantities such as signal-to-noise ratios, system sensitivity, and sampling limitations are available in the literature. When applied to research with the *Dunaliella* cells, the technique contains one important underlying assumption--namely, that there is a *time-stable* (however small) component to the cell velocities that may correlate with the participant's effort. To clarify the technique, we will use an example from central nervous system (CNS) research. To measure a visual evoked response, the following steps are performed:

1. A light is flashed in a subject's eyes (the event).
2. Occipital EEG is measured every millisecond for 250 ms (the time series data).
3. Steps 1 and 2 are repeated for approximately 100 flashes--the data from each step are averaged into the preceding data.

If there is no *time-stable* component of the occipital EEG to the light flashes, the data will average to zero. What is found, of course, is that in some fraction of the population, a persistent signal survives the averaging. That signal is called the visual evoked response.

To apply this technique to the *Dunaliella* experiment, let us assume that we have measured the cellular velocities, V, average over [q] cells (RA condition). Further, assume that we have [n] number of events (similar to the light flash above) consisting of single button presses by the participant to initiate a trial consisting of [m] velocity measurements.

Figure 1 shows a matrix of data that can be constructed from such a situation.

V_{jk} is the velocity measurement at time [k] for each button press [j], and t_k (k = 1,m) represents the kth data point (after all the data have been detrended). As in the CNS research example, we average the velocities across all button presses for each data point to produce column means (the V-bars in this example). The row means, V-bars, will be discussed below. A similar data matrix can be constructed when the apparatus is completely unattended (the MCE condition). We must now determine if the RA matrix is significantly different from the MCE matrix. An Analysis of Variance (ANOVA) technique is the appropriate statistic to use to understand this situation. An ANOVA can determine:

1. If the RA-condition column means differ significantly from the MCE-condition column means (an ANOVA interaction term).

2. If the variation observed in the RA-condition column means is highly significant.

Button Press	t_1	t_2	. . .	t_{m-2}	t_{m-1}	t_m	
1	V_{11}		. . .				$\overline{V}_1$
2			. . .		V_{jk}		$\overline{V}_2$
⋮	⋮	⋮		⋮	⋮	⋮	⋮
n	V_{n1}		. . .			V_{nm}	$\overline{V}_n$
	$\overline{V}_1$	$\overline{V}_2$	. . .			$\overline{V}_m$	

FIGURE 1 SIGNAL AVERAGING DATA MATRIX

The second case above is particularly interesting. If the number of button presses is large, and if the RA-condition means are *highly* significant (i.e., ~ $p < 10^{-15}$), then there is *strong* evidence in favor of a causal interaction rather than an IDS process. IDS is *not* a competing process if a system possesses a nearly infinite signal-to-noise ratio--the case that is required if item (2) above is true.

Under the condition that the ANOVA shows a significant interaction between the RA and MCE conditions, then a second analysis is imperative when working with *Dunaliella*. The problem is that the V_{jk}s are *not* necessarily statistically independent and cannot be considered random variables in the usual sense. By ignoring possible persistent temporal components to V_{jk} (i.e., the 24- hour circadian rhythm), *Forbush et al.*[3] demonstrated that a *gross* underestimate of the residual variance may occur leading to a highly inflated F-ratio from the ANOVA. In their test example in geomagnetic data, the inclusion of a correction for a known temporal persistency reduced the F(26,3874) ratio from 4.96 to 1.16 (a p-value increase from 10^{-15} to 0.3)! *Forbush et al.* suggest that a variance correction must be made. Although there are a number of different techniques to provide a variance correction, the technique that *Forbush et al.* suggest provides a quantitative estimate of a "coherence length" beyond which a variance correction is not needed. Thus, it is possible to determine experimentally if the circadian rhythm (or any other periodicity) is confounding the interpretation of the data.

C. IDS Considerations

It is possible that the above technique will simplify the IDS aspect of the experiment. Suppose a participant produces [n] button presses each resulting in [m] data points (average velocity over [q] cells each). Suppose further that associated with such a data matrix is an identical MCE matrix (possibly collected just before to the participant's first button press). For the purpose of an IDS analysis, we consider this situation as [n] data points in which the independent variables are all equal to [m] and the dependent variable is given by

$$\bar{V}_m^c - \bar{v}_j(m) ,$$

where $\bar{V}_m^c$ is the grand mean for the MCE matrix where the number of columns is [m], and $\bar{v}_j$ is the row mean for the jth of the [n] data points described above.

If we collect a number of such data sets by allowing [m] to vary, then using the IDS formalism, the IDS and RA hypotheses will produce the curves that are shown in Figure 2.

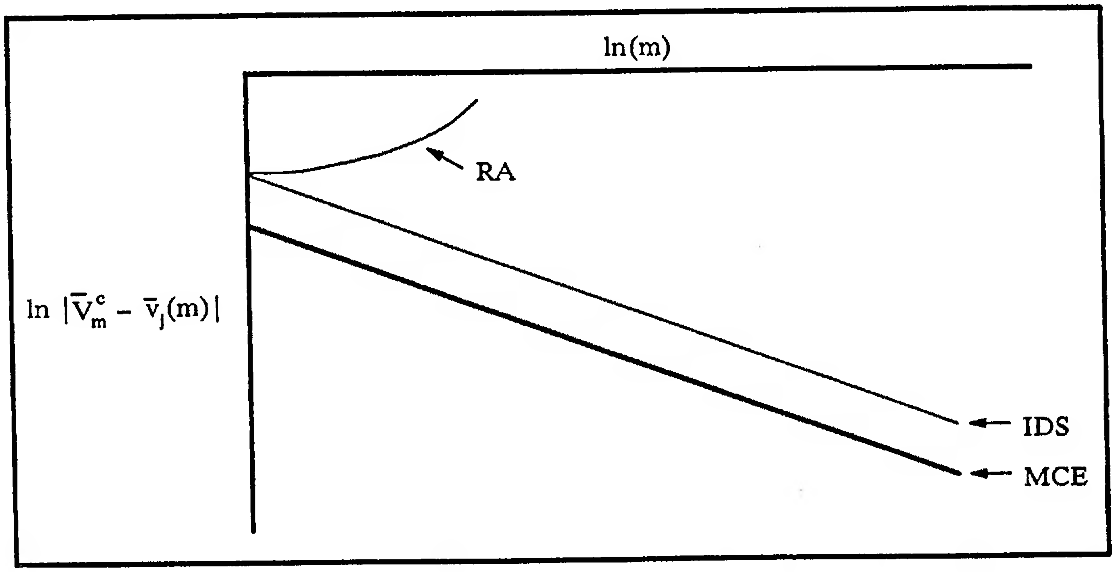

FIGURE 2 PREDICTIVE CURVES FOR THE RA AND IDS HYPOTHESES

If our initial assumption is incorrect (i.e., that there are no psychoenergetic effects), then the data will lie along the MCE curve shown in Figure 2. If, however, there is a psychoenergetic effect that can be described by an informational process, then the data will lie along a straight line with the same slope (−0.5) as the MCE line, but with a significantly different intercept. Should the effect prove to be causal, then the data are expected to lie along a curve similar to the RA curve.

One advantage of working with a living system as an RA target, is that, in this case, a known cause-and-effect relationship can act as an RA-like control. If the shift of the velocity distribution because of the phototropic behavior of the cells can be determined, then the phototropic data as a function of [m] can be calculated in advance.

Thus, if the phototropic data lie along the predicted RA-like curve and the data produced by a participant lie along the IDS curve, then we should have compelling evidence in favor of the IDS hypothesis.

IV CONCLUSIONS

By using the most powerful statistical techniques available, psychoenergetic effects if present, can be observed in this exceptionally noisy system. If psychoenergetic effects can be verified, we believe that the experiment conducted by Dr. Pleass constitutes one of the most important tests of the IDS hypothesis.

REFERENCES

1. May, E. C., Humphrey, B. S., and Hubbard, G. S., "Electronic System Perturbation Techniques," Final Report, SRI International, Menlo Park, California (September 1980).
2. Chree, C., "Some Phenomena of Sunspots and of Terrestrial Magnetism–Part II," *Phil. Trans. Roy. Soc. London,* Vol. 213A, pp. 245–277, (1913).
3. Forbush, S. E., Pomerantz, M. A., Duggal, S. P., and Tsao, C. H., "Statistical Considerations in the Analysis of Solar Oscillations Data by the Superposed Epoch Method," *Solar Physics,* Vol. 84, pp. 113–122 (1983).

Appendix

BIO LASER DOPPLER CONSCIOUSNESS RESEARCH

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A Progress Report for 1985-1986

to

SRI International

Contract No. C-11498

BASELINE DATA

A study of the structure of 1985 baseline velocity data derived from cultures of the motile marine alga *Dunaliella* has shown that any given data string may or may not exhibit trend, abrupt mean shifts, periodicity, or any combination of these. Examples are given in the Annex.

Only the diurnal (or circadian) rhythm is consistently manifest. Because it is long compared to the duration of a typical set of psi runs, it normally appears as trend in the data strings that report the velocities. Figures 1 and 2 show 24 hours of velocity and vector data from *Dunaliella*. The correlation between circadian phase angle, the expected magnitude of the observed velocity, and the direction of motion is evident.

Our 1986 baselines are "quieter" and rarely show abrupt mean shifts or periodicity, other than the trend that derives from the circadian rhythm. This results from changes in laboratory practice described in the section on microbiology.

PROTOCOL FOR AN IDS EXPERIMENT

A protocol has been developed for 1986-87 studies of the IDS hypothesis. The protocol allows the participant (we choose to use the word participant, instead of the more usual term operator, to try to encourage a synoptic view of the experiment) to determine the length of the psi run, which is marked on the evolving data string by using preprogrammed keys on the computer keyboard. The participant touches the key Fl when they are ready to begin the psi run, and the key F10 at the end. The psi task has been to visualize the algae at the laser beam crossover, and the variable is the resolved value of the algal velocity. We ask participants using this procedure to end their runs as abruptly as possible, the moment that an intrusive thought diverts their attention. They then read a dictionary while control data evolves. Figure 3 illustrates a hypothetical set of three runs. Note that while the participants are given a cue on the monitor at the end of the minimum control period B, they may be engrossed in Webster's definition of fescennine and, therefore, choose to delay their next run.

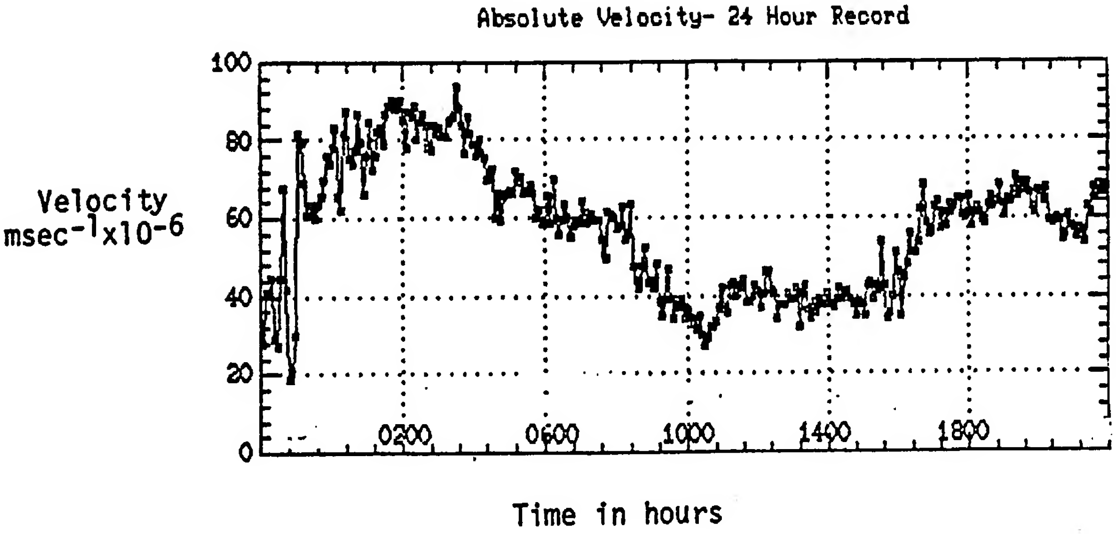


FIGURE 1

Circadian Variation in Dunaliella in Swimming Velocity
During the First 24 Hours in Continuous 6328Å Light

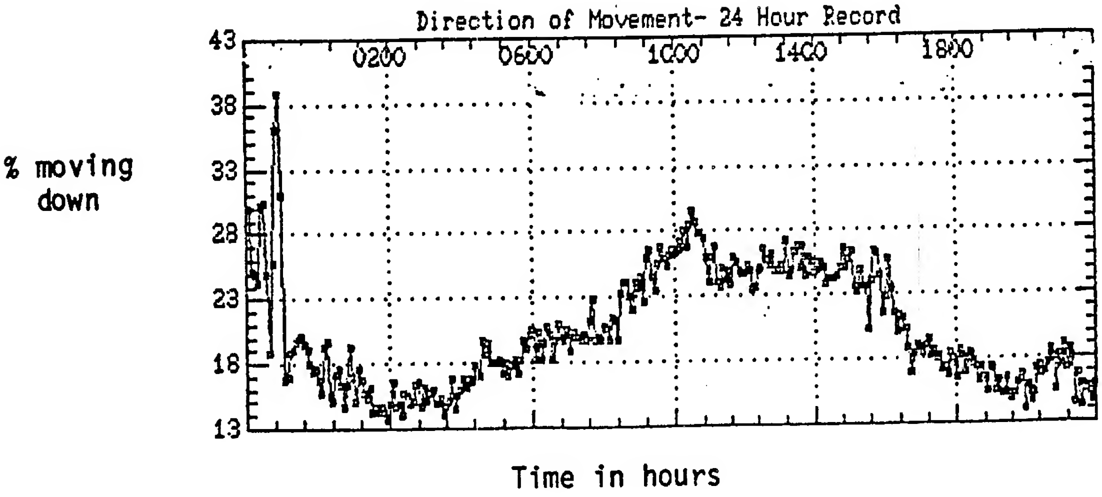
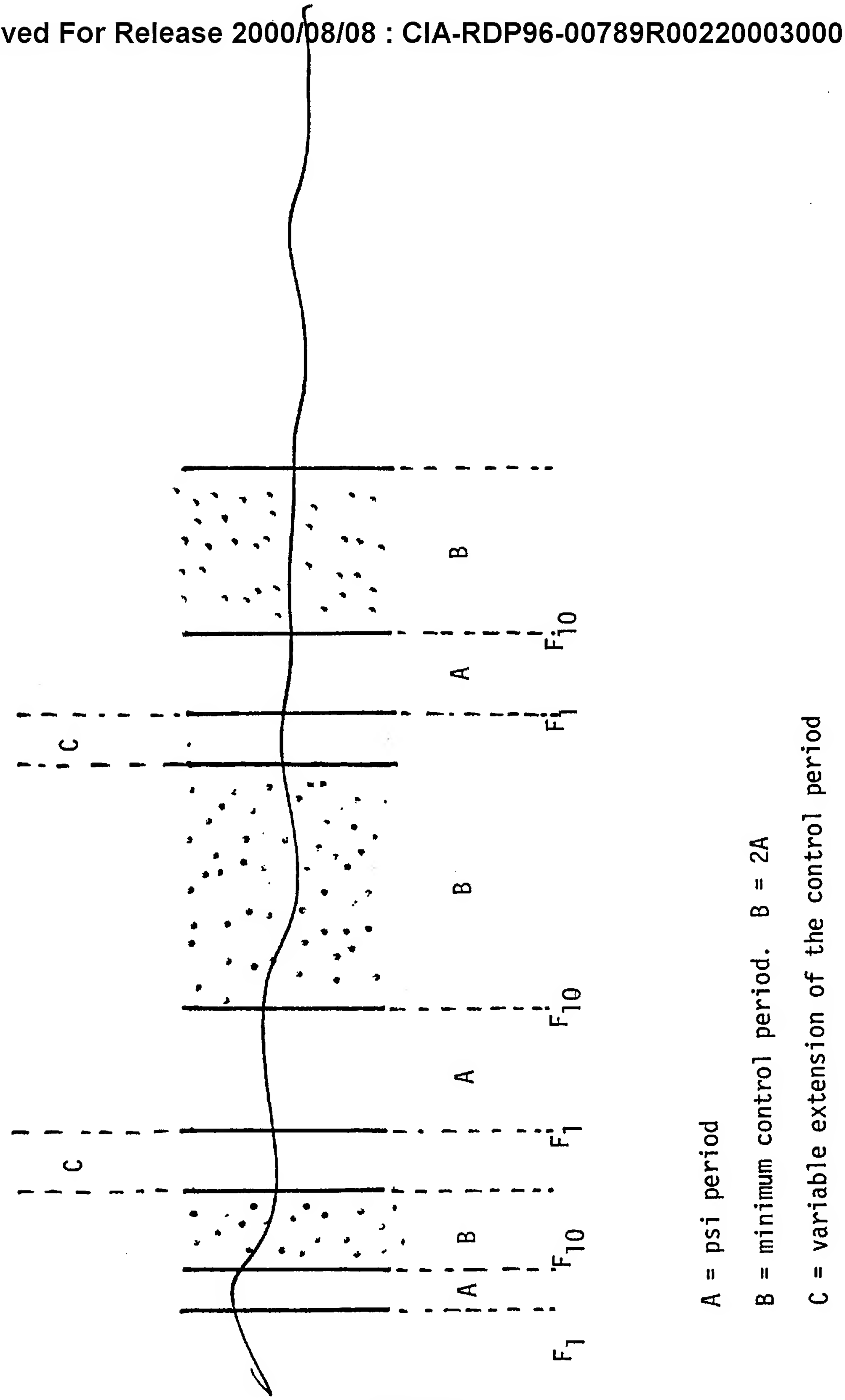


FIGURE 2

Circadian Variation in Dunaliella in Direction of Motion
in the First 24 Hours in Continuous 6328Å Light



A = psi period

B = minimum control period. B = 2A

C = variable extension of the control period

FIGURE 3

Format for PK86

Feedback is provided at the end of each session, in the form of a plot of V psi minus V control for each run within the set.

This procedure is likely to result in run times varying from 30 seconds to 10 minutes, with clustering around 1 to 4 minutes. However, we want to start in this mode. In the 1986–87 proposal there is a flow chart of the proposed research and notes about future trials with sequence lengths at equally spaced intervals of log (sequence length), and experiments in which psi alternates with light.

STATISTICAL PROCESSING

Because trend in the data is the norm, statistical processing starts with detrending. The method used through most of 1984–85 involved double differencing and is described in the Annex. In early 1986, a more straightforward technique was developed; all data are regressed onto a line, and the slope of this line is then used to detrend each datum. Somewhat to our surprise, detrending in this way does not blur the structure of plots of run scores (Figures 4 and 5).

After detrending, the data are processed in the simplest possible manner by using the difference in the mean velocity during the psi and control periods as the "score" for the trial. Because there will normally be a "score," even if there is no psi mediation, individual values of [psi–control] do not relate exclusively to the null hypothesis that there is no psi effect; they are qualitative indicators. Histograms of these scores are also inconclusive until they are compared to equivalent histograms prepared from data strings that have no psi mediation at all. In 1986 we have chosen to take this "global control" data on the following day at exactly the same circadian phase angle (time). The technique used is to transfer the time markers from the real psi and control data string to the global control string. This global control data accumulates while the experimenter is doing other work in adjacent laboratories, blind to the process.

One way of comparing accumulated experimental and global control data to see if there is evidence of a psi effect is to describe Gaussians that best fit the histograms, and then compare the experimental to the global using a F test. We are presently moving away from this approach because the distributions of experimental data are so non-normal, but it is informative to use this approach to check that detrending by regression does not change results originally obtained by detrending using double differencing.

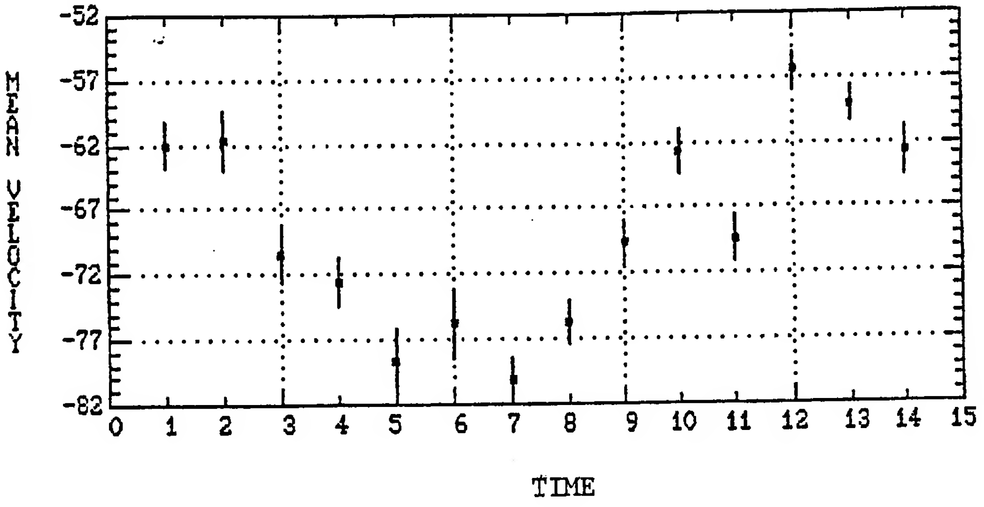


FIGURE 4

Standard Error Bars For Test 706 – Raw Velocity

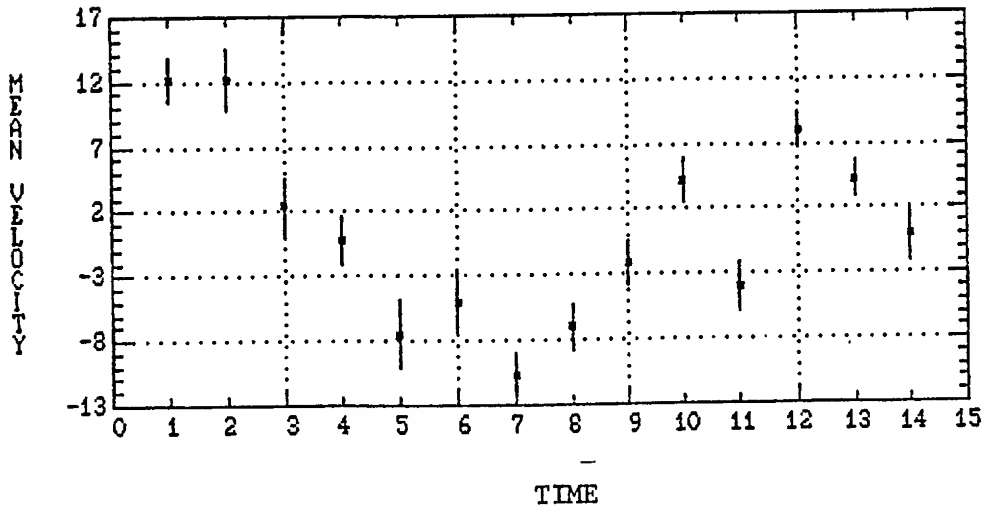


FIGURE 5

Standard Error Bars For Test 706 – Detrended Velocity

Figure 6 records F tests on the output from these two different analyses. Because the data are not normally distributed the p values which result from the F test are only indicators, but they are both low, and remarkably similar.

The PK86 data comes from much quieter baselines (see microbiology) and the global data are quite a good approximation to a normal distribution, with $X^2 = 0.44$ (Figure 7). The experimental data (Figure 8) have the characteristic non-normal distribution that we are beginning to recognize as evidence of response to a stimulus. Once again, the F test is only an indicator, but the numbers are quite encouraging.

$$F = \frac{\text{EXPERIMENTAL}}{\text{GLOBAL}} = 2.64, \quad \text{DF} = 176/158$$

$p < 10^{-6}$ (Statgraphics limits!)

Note that like the old WAVE data given in the Annex, the PK86 data have larger variance in the experiment. PK85 data still seem to reflect one participant's tendency to calm the algae (Annex, page 16). As the other individual data bases grow, we will be able to sort this out.

Spontaneous variation in the duration of our 1985-86 psi runs has provided an opportunity for a preliminary examination of the variation of the psi score with sequence length. Figures 9 through 12 show plots of PK85 and PK86 scores against sequence length with the corresponding globals. (Watch the varying scale on the ordinate caused by the software used). As yet, we do not feel we have enough data or enough spread in sequence length to form even tentative conclusions: that will be a task for 1986-87.

$$\text{PK85 F} = \frac{\text{GLOBAL CONTROL}}{\text{EXPERIMENTAL}}$$

CASE 1 - PK85 data detrended and scored by double differencing:

$$(\bar{V}_{\text{control}} - \bar{V}_{\text{psi}}) - (\bar{V}_{\text{pseudocontrol}} - \bar{V}_{\text{pseudopsi}})$$

$F = 1.64$, 204 DF

$p = 2\text{x}10^{-4}$

CASE 2 - PK85 data detrended by regression, then scored as:

$$\bar{V}_{\text{psi}} - \bar{V}_{\text{control}}$$

$F = 1.707$, 204 DF

$p = 7\text{x}10^{-5}$

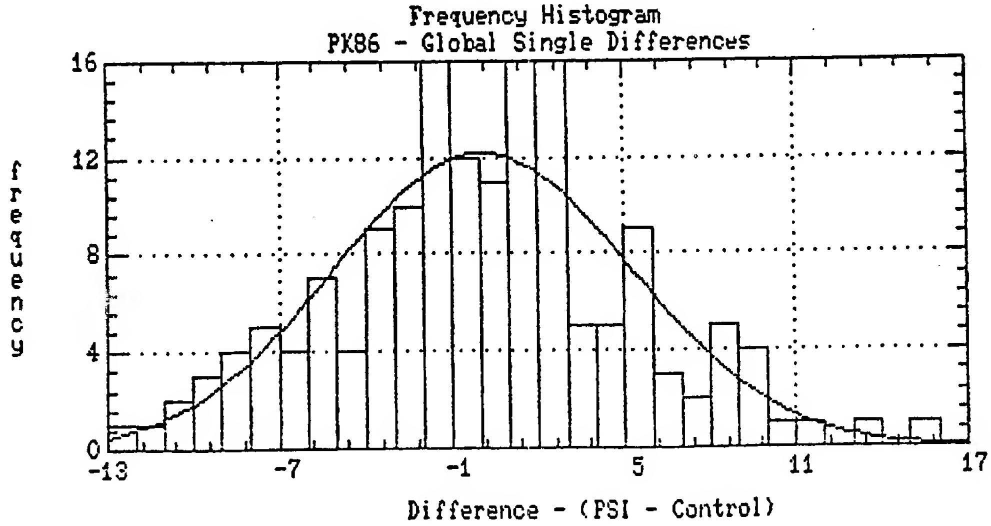
FIGURE 6

F Tests On Best Fit Gaussians From Histograms of Scores

```
ENTER THE NAME OF THE VARIABLE CONTAINING YOUR DATA:  DELTA
NUMBER OF OBSERVATIONS = 158  (2 MISSING VALUES EXCLUDED)
SAMPLE AVERAGE = 0.066076
SAMPLE VARIANCE = 26.755
SAMPLE STANDARD DEVIATION = 5.1725

MINIMUM VALUE = -12.353   MAXIMUM = 15.167   RANGE = 27.52
LOWER AND UPPER QUARTILES = -3.1363 2.8868
INTERQUARTILE RANGE = 6.0231
MEDIAN = 0.029543

COEFF. OF SKEWNESS = 0.11154   STANDARDIZED VALUE = 0.57237
COEFF. OF KURTOSIS = 3.0251   STANDARDIZED VALUE = 0.064358
Press ENTER to continue.
```



```
ESTIMATED PARAMETERS: 0.066076 5.1725
CHI*2 GOODNESS-OF-FIT STATISTIC = 15.147 WITH 15 DEGREES OF FREEDOM
PROBABILITY OF A LARGER VALUE = 0.4409
```

$$\Delta = \bar{V}_{"psi"} - \bar{V}_{"control"}$$

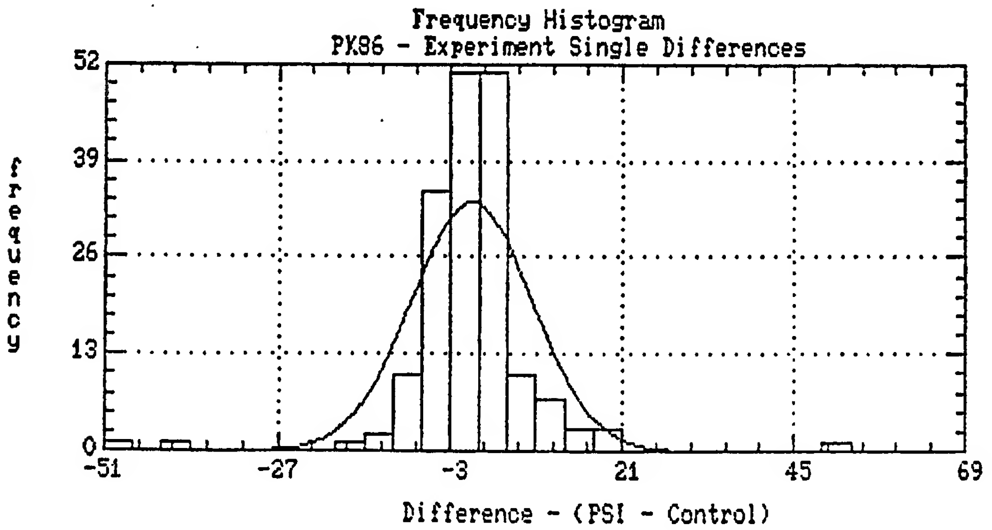
FIGURE 7

Global PK86 – Detrended By Regression

```
ENTER THE NAME OF THE VARIABLE CONTAINING YOUR DATA:  DELTA
NUMBER OF OBSERVATIONS = 176  (0 MISSING VALUES EXCLUDED)
SAMPLE AVERAGE = -0.031364
SAMPLE VARIANCE = 70.551
SAMPLE STANDARD DEVIATION = 8.3995

MINIMUM VALUE = -50.165   MAXIMUM = 49.546    RANGE = 99.71
LOWER AND UPPER QUARTILES = -3.5909 3.0301
INTERQUARTILE RANGE = 6.6209
MEDIAN = -0.083973

COEFF. OF SKEWNESS = -0.48565   STANDARDIZED VALUE = -2.6303
COEFF. OF KURTOSIS = 18.356   STANDARDIZED VALUE = 41.585
Press ENTER to continue.
```



```
ESTIMATED PARAMETERS: -0.031364 8.3995
CHI*2 GOODNESS-OF-FIT STATISTIC = 50.005 WITH 6 DEGREES OF FREEDOM
PROBABILITY OF A LARGER VALUE = 4.6902E-9
```

$$\Delta = \bar{V}_{psi} - \bar{V}_{control}$$

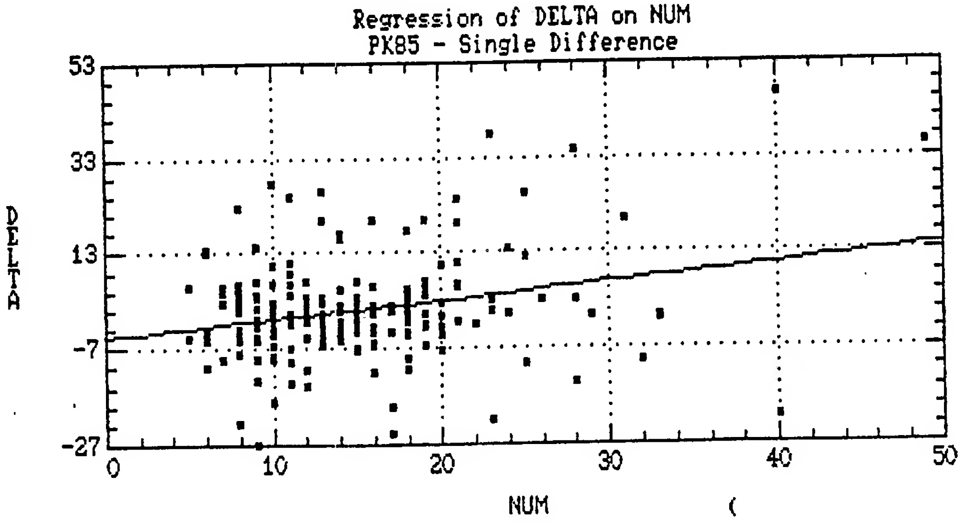
FIGURE 8

Experimental PK86 – Detrended by Regression

```
Simple Regression of DELTA on NUM
                                     Standard             T                Prob.
Parameter          Estimate            Error            Value              Level
------------------------------------------------------------------------------------
Intercept           -4.6399            1.7187          -2.6996          7.5254E-3
Slope               0.38384           0.10726           3.5785          4.3169E-4

------------------------------------------------------------------------------------
                        Analysis of Variance
------------------------------------------------------------------------------------
Source                  Sum of Squares     Df    Mean Square      F-Ratio
Model                        1308.7197      1      1308.7197      12.8059
Error                        20848.099    204        102.197
------------------------------------------------------------------------------------
Total (Corr.)                22156.818    205

Correlation Coefficient = 0.24304
Stnd. Error of Est. = 10.109
```



Δ = Score; NUM = Sequence length

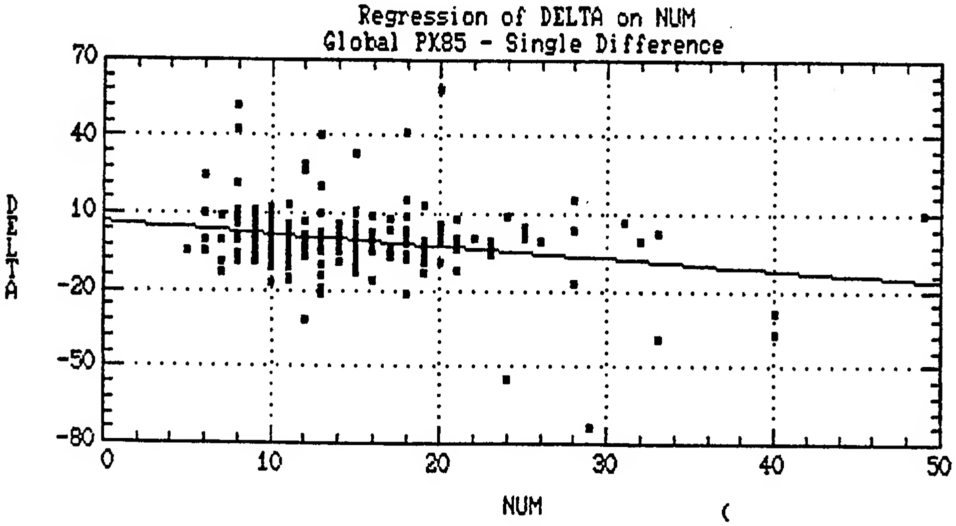
FIGURE 9

Experimental PK85 - Detrended By Regression

```
Simple Regression of DELTA on NUM
                                  Standard            T               Prob.
Parameter          Estimate        Error            Value             Level
------------------------------------------------------------------------------
Intercept            6.6804        2.2524           2.966         3.3755E-3
Slope              -0.45958        0.14074         -3.2654        1.2812E-3

------------------------------------------------------------------------------
                      Analysis of Variance
------------------------------------------------------------------------------
Source                Sum of Squares      Df   Mean Square     F-Ratio
Model                      1878.9294       1    1878.9294      10.6627
Error                      36123.957     205      176.214
------------------------------------------------------------------------------
Total (Corr.)              38002.886     206

Correlation Coefficient = -0.22236
Stnd. Error of Est. = 13.275
```



Δ = Score; NUM = Sequence length

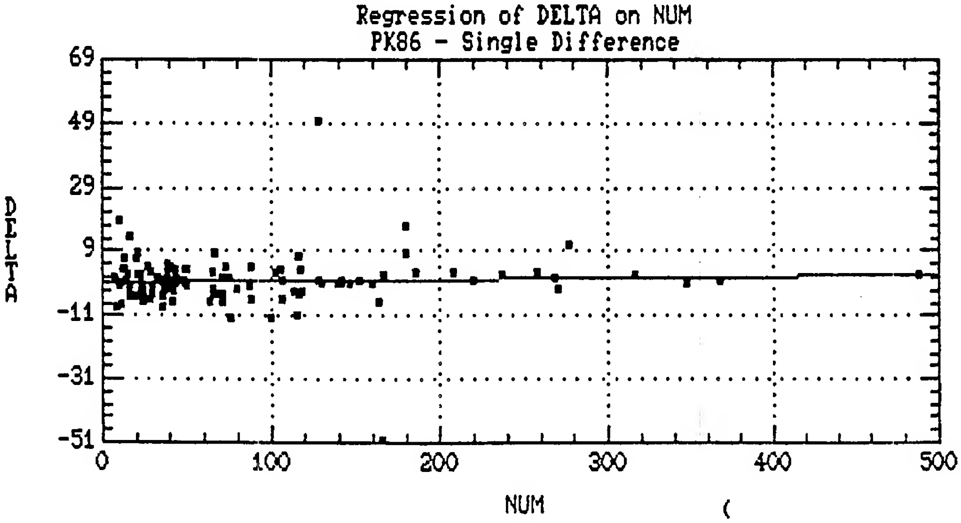
FIGURE 10

Global PK85 – Detrended By Regression

```
Simple Regression of DELTA on NUM
                                     Standard               T            Prob.
Parameter          Estimate            Error              Value           Level
-------------------------------------------------------------------------------
Intercept          -0.48485            1.1132          -0.43553         0.66402
Slope             4.5057E-3          9.1509E-3          0.49238         0.62342

-------------------------------------------------------------------------------
                          Analysis of Variance
-------------------------------------------------------------------------------
Source                   Sum of Squares      Df   Mean Square      F-Ratio
Model                         16.988159       1    16.988159       .242439
Error                         7777.9715     111      70.0718
-------------------------------------------------------------------------------
Total (Corr.)                 7794.9596     112

Correlation Coefficient = 0.046684
Stnd. Error of Est. = 8.3709
```



Δ = Score; NUM = Sequence length

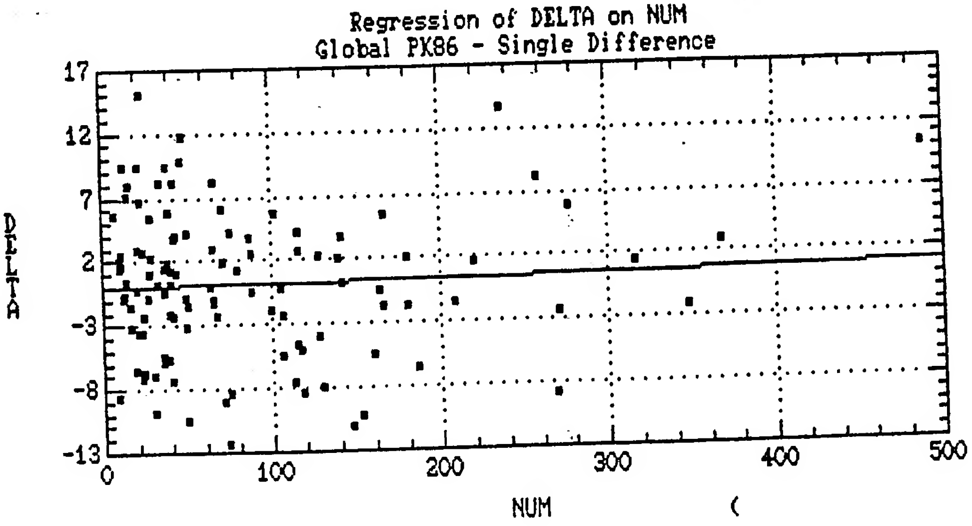
FIGURE 11

Experimental PK86 – Regression

```
Simple Regression of DELTA on NUM
                                      Standard              T               Prob.
Parameter           Estimate           Error              Value             Level
---------------------------------------------------------------------------------
Intercept           3.8801E-3          0.75413          5.1452E-3           0.9959
Slope               2.0449E-3          6.1989E-3          0.32987           0.74212
---------------------------------------------------------------------------------

---------------------------------------------------------------------------------
                         Analysis of Variance
---------------------------------------------------------------------------------
Source                    Sum of Squares      Df     Mean Square       F-Ratio
Model                        3.4990537         1      3.4990537       .1088168
Error                        3569.2564       111        32.1555
---------------------------------------------------------------------------------
Total  (Corr.)               3572.7555       112

Correlation Coefficient = 0.031295
Stnd. Error of Est.  = 5.6706
```



Δ = Score; NUM = Sequence length

FIGURE 12

Global PK86 – Regression

PARTICIPANT POOL CHARACTERISTICS

Our present pool of participants (33) is drawn from professionals (both scientists and not), young adults, and non-professional adults.

There are about eight principal participants who will probably do most of the SRI work. None profess psychic ability. All have come to us by "networking" with others closer to the research. We have held an informal lunch-hour seminar to allow them to meet and comment on the program. Psychological evaluation of the participants will be carried out by Dr. David Saunders of MARS Measurement Associates. Formal psychological evaluations will not begin until a participant has completed an experimental series (10 sets) or shown unmistakable evidence of long-term commitment.

COMMUNICATION WITH SRI

Our PK85 and WAVE data bases and the corresponding global control data have been shared with SRI International and Dr. Jessica Utts. Dr. Edwin May, SRI, suggested an interesting approach to data processing based on a technique of epoch analysis first reported by Chree,* and now widely used in identifying rhythms in geomagnetic data. Because two of the authors of a recent substantial paper on Chree's analysis are from the University of Delaware, they were contacted, and a seminar was held. While the conclusion was that sequential events in our present data files were independent, and that Chree's analysis was unlikely to be immediately useful, it may well come in handy in future work with low-level conventional stimuli (like light), applied rhythmically. The seminar served a second very useful purpose: it exposed the work to three more senior faculty in the Physics Department. The response was positive and encouraging. The climate seems to be changing, perhaps because the data are so robust and the physics of the method so tightly defined.

The computer network seems to be functional. Dr. Dean Dey uses it to leave messages at SRI, and we will try to use it increasingly. I am hoping that all modes of communication can be enhanced in 1986-87; we want to keep in close contact to promote the free exchange of ideas.

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*Chree, C., "Some Phenomena of Sunspots and of Terrestrial Magnetism - Part II," *Phil. Trans. Roy. Soc. London*, Volume 213A, pp. 245-277 (1913).

MICROBIOLOGY

During 1985, we made some substantial improvements in our technique for culturing *Dunaliella* and transferring aliquots to the laser room. By using laminar flow hoods, sterile techniques, and extensive rinsing of vessels that have been acid-cleaned, we have reached a point at which cultures can be kept in the laser room for more than 24 hours without appreciable deterioration. This technique gives us the option of inserting new samples just before 4:30 p.m. each day, so that we are ready for data collection the following day. Baselines obtained in this way are much quieter. This effect can be observed in Figure 8, the global control for the 1986 data. We are pleased to find that the differences that represent the "scores" are almost normally distributed.

CONCLUSION

A protocol has been developed that allows the compilation of data relating sequence length and psi "score." Pilot runs contain strong evidence of a psi effect, and the results have indicated some tentative, but interesting, suggestions of variation of score with sequence length. Details of work to be carried out in 1986-87 will be discussed before data collection.

ANNEX 1

BEHAVIORAL RESPONSE OF MICROORGANISMS TO psi STIMULUS
PART II: STATISTICAL ANALYSES OF DATA FROM DUNALIELLA

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ABSTRACT

A consciousness experiment in which the Doppler shift of He/Ne laser light was used to describe changes in the velocity and vector of a marine alga, Dunaliella, was reported by Pleass and Dey in 1985. Because the subject of the consciousness experiment is living, we expect strings of baseline velocity and vector data which are, at some level, inexplicably time-variant. This complexes the statistical procedures which must be used to analyze the data.

This paper examines the variation in baseline data strings, and describes two alternative statistical procedures which have been used to determine the probability of consciousness effects. Two levels of control are applied, allowing global comparison of frequency distributions of experimental scores with similar distributions derived artificially from baseline data. In both cases the null hypothesis is that there is no psi effect. The data quite strongly suggest the rejection of the null hypothesis.

BEHAVIORAL RESPONSE OF MICROORGANISMS TO psi STIMULUS

PART II: STATISTICAL ANALYSES OF DATA FROM DUNALIELLA

INTRODUCTION

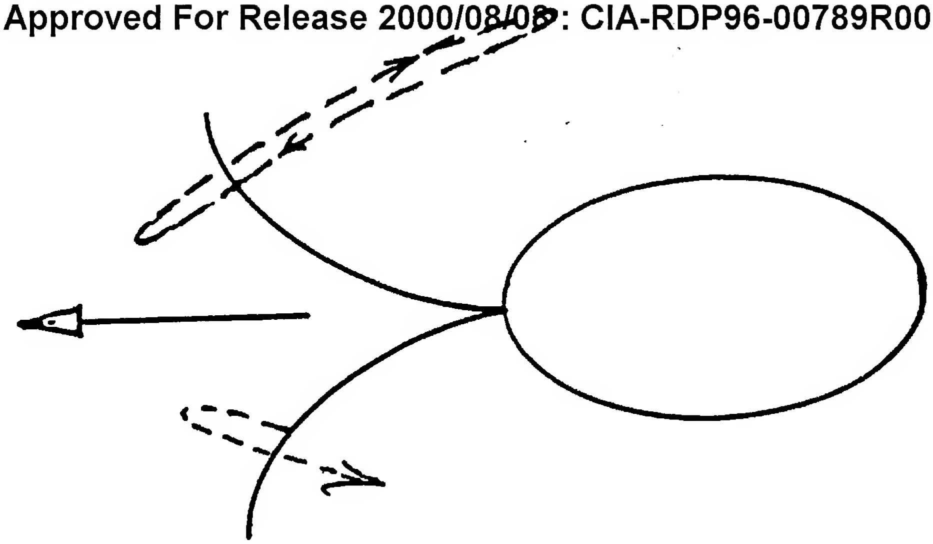
The College of Marine Studies of the University of Delaware have over a decade of experience with the culture of marine microalgae. Initially, these cultures were prepared as experimental diets for oysters in controlled environment mariculture. In 1982, Pleass and Dey began a series of studies of the response of a hardy green alga, Dunaliella to psi stimulus, using the Doppler shift of scattered laser light as a rapid, accurate measure of the change in swimming velocity and direction of individual cells. The apparatus and techniques used were described at the 28th Parapsychological Association Convention and published in the Proceedings (Pleass and Dey 1985). This reference should be taken as Part I in an ongoing series. It contains secondary references relevant to the experiment per se.

In summary, cells of Dunaliella are approximately 10^{-5} m in length. Using whiplike flagella in a motion similar to breast stroke, they swim at velocities up to ca. $2x10^{-4}$ $msec^{-1}$ (Figure 1). The laser Doppler apparatus uses a He/Ne laser in the mode illustrated in Figure 2. The measuring volume is the ellipsoid where the split laser beams cross. It has a volume of ca. $1x10^{-6}$ cc. Cultures of Dunaliella can easily sustain 10^6 cells per cc, with intercellular spacing of the order of 10^{-4} m. Under these conditions, bursts of scattered light from the laser crossover will normally correspond to the passage of one individual cell. On the rare occasions when the measuring volume contains more than one, the observed velocity will be the mean. Data rates are quite high, ca. 70 sec^{-1}, depending on the cell concentration and the average motility. The apparatus is single-component: it will record velocity and direction along any one chosen axis. Since algae frequently migrate vertically in response to circadian rhythms, the vertical axis is normally used, and it may be assumed unless an alternate is specified. The apparatus is interfaced with an IBM PC and baseline data are normally stored as the average of 100 or 200 velocity readings.

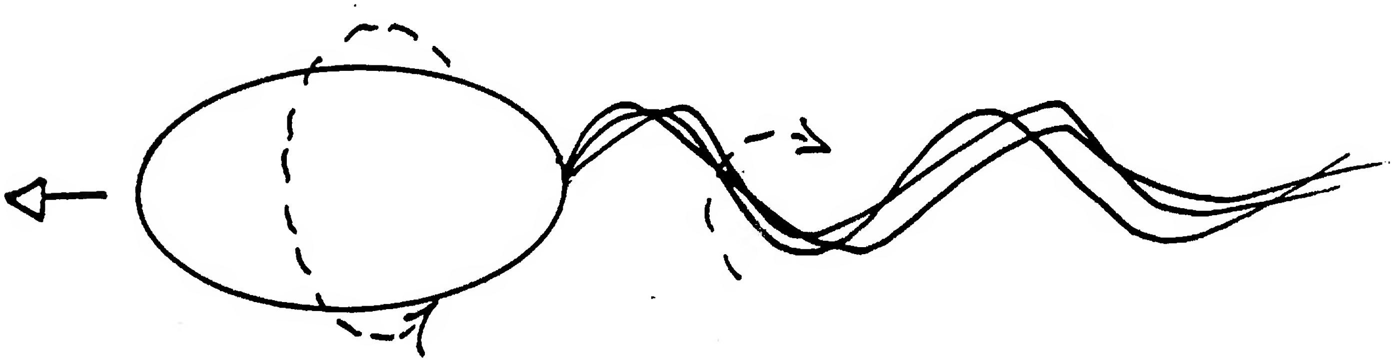
Laser Doppler studies of the circadian rhythms displayed by motile marine algae have been described (Pleass and Dey 1985). Baseline data describing algal velocities must be assumed to contain trend, rhythm and nonrandom noise, and this complexes the preparation of statistics describing the results of experiments whose objective is to record behavioral response to an exogenous stimulus. This paper will focus on this problem using results obtained from consciousness experiments with Dunaliella.

The most fundamental point, which is rarely found explicitly stated in the literature, is that any experiment with a living system is by definition, irreproducible. In fact, the hard physical sciences which derive from observation of inanimate structures, and the application of logic, encourage an invalid extrapolation: that precise replicability is a sine qua non of experimental science.

Theoretically, every observation must ultimately reduce to a probabilistic conclusion, in part because of the Heisenberg uncertainty principle, and in part because no system can be conceived which is perfectly stable through time at any temperature above absolute zero. This point has been widely recognized in the writings of many distinguished physicists and philosophers. Jahn and Dunne have brought these together in an excellent treatment of the "quantum mechanics of consciousness." (Jahn and Dunne 1984) which may provide a starting point for a formal theory of consciousness.



Flagella at the front end, approximating a breast stroke. Jerky forward motion. Examples are Dunaliella and Chlamydomonas.



Flagella at rear end, rotating like a propeller on a natural universal joint. The body counter-rotates slowly.

Figure 1
Two common propulsive mechanisms used by microorganisms

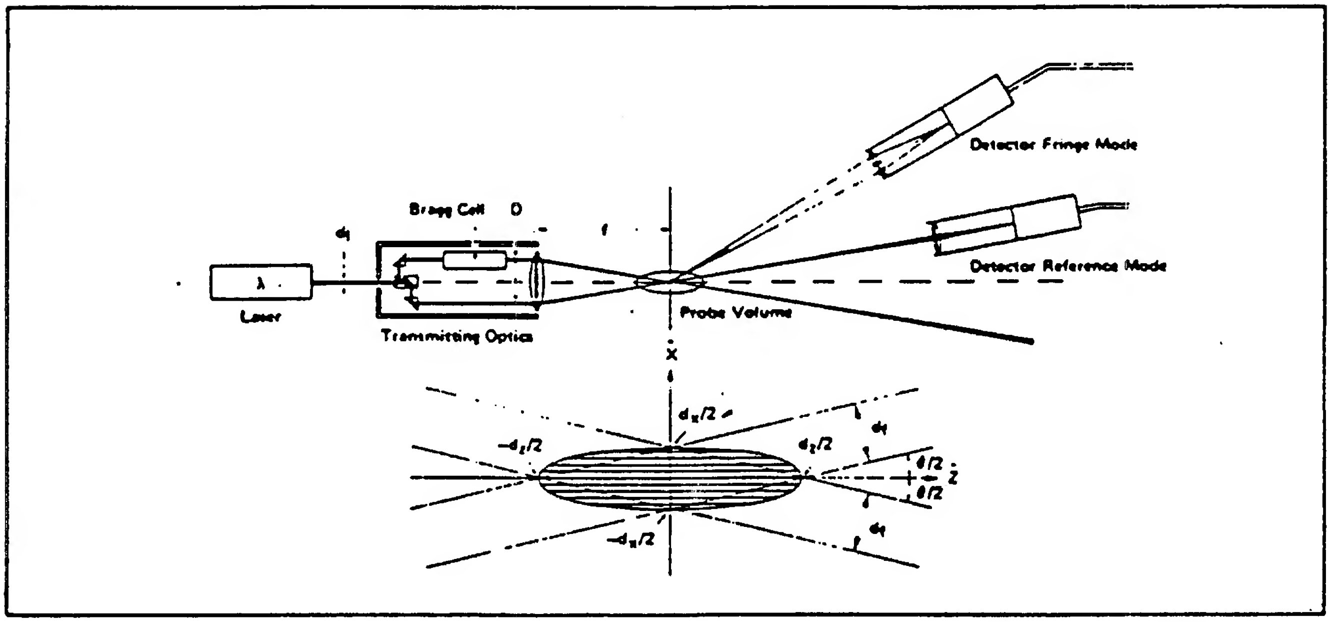


Figure 2
Single-component, fringe mode LDA probe volume

Nonliving systems change their visible form through time in response to physical and chemical laws. Since the kinetics of many of the reactions involved in these changes are slow, relative to human lifetimes, we may conveniently speak of replicable changes such as the expansion of a bar of pure metal which is subjected to a standard rise in temperature.

This allows us to distinguish living systems as those which change measurably in response to endogenous stimuli within the time span of human observation. Challenging these definitions is interesting. A bacterium falls in the category of living, and a macromolecule does not. The key to the separation is that we can, at least in theory, explain the movements of the macromolecule as the result of environmental (exogenous) stimuli such as molecular collisions and changes in van der Waals forces. When we observe a bacterium we cannot escape the conclusion that endogenous stimuli are involved in determining its behavior. It may absorb chemicals from solution to acquire information suggesting a preferred direction of motion, but that by itself cannot explain its time-variant behavior such as its "run-and-twiddle" pathway.

This commentary is relevant to the analysis of velocity and vector data from Dunaliella. Because it is living, we must expect data from our BLD experiments which is inexplicably time variant. Only in the most general case such as 24 hour circadian rhythm will a consistent pattern be visible. If data from successive psi and control periods are to be accumulated, statistical protocols which "see through" trend and rhythm become most important: without them meaningful results cannot be expected unless the data extends many times the length of the longest cycle, and runs are randomly distributed in time.

The general question of rhythmic changes which could possibly be anticipated by a participant in a psi experiment must be thoughtfully addressed. In biological experiments which have paralleled our psi research we have sought for, but failed to find replicable rhythms other than the circadian or "diurnal". This was an important prerequisite to the experiments to be discussed. If, for example, time series analysis had revealed a subtle replicable rhythm with a ten minute period, this information would allow an informed participant who wished to create an artificially high score to execute psi runs at ten minute intervals. Fortunately, the only relicable rhythm has such a long period (24 hours) that it cannot be used to advantage. It is manifest in the data strings as a trend. Note that most participants choose to work in the mornings at approximately the same circadian phase angle. The data is detrended by our statistical protocol.

The most relevant reference to other current work seems to be to May et al., (1985), and references therein. These authors offer evidence for an informational model called Intuitive Data Sorting (IDS) in which individuals "sort" locally deviant sequences from a random sequence into significant and non-significant bins. Although their data were derived from a meta-analysis of binomial data (Radin et al., 1985) the concept of IDS provides an intellectual "foothold" for someone interested in examining our data. Secondary references within these two papers are also useful.

RESULTS

Since the statistical results developed in this section are quite robust, the reader may wish to consult Appendix 1 which describes the precautions taken to ensure target system and data security. This information complements the description of the laboratory and the method given in Pleass and Dey (1985).

Baseline Data Properties

The understanding of the statistical properties of our baseline data stream is an essential and ongoing endeavor. Baseline data, meaning a stream of velocity readings taken by the computer when neither participant nor experimenter are present in the laboratory, have been collected and subjected to numerous visual inspections (via time plots) and more quantitative analyses. Note that the examples given in this section are chosen to represent extreme cases. With that caveat, the following properties have been found to exist in our "normal" baseline:

A. Noise - the variation of velocity readings around an average value. This variation is neither a constant nor a constant percentage of the average. Standard deviations (σ) of baseline velocity readings range from 5 to $35\text{x}10^{-6}$ msec^{-1} with coefficients of variation $100\sigma/\bar{x}$ from 10 to 60 percent. A particularly disconcerting example of baseline noise is shown in Figure 3, where noise appears to consistently increase for approximately two hours.

B. Trends - where velocity is consistently increasing or decreasing for periods of several hundred to several thousand readings. Figure 4 shows two examples of long term (decreasing) trends in baseline velocity readings.

C. Periodicity - repeating cycles of varying frequency. Periodicity includes strings of velocity readings with significant autocorrelation. Figure 5 is an interesting example. In the raw velocity readings, Figure 5A, periodicity is nearly obscured by noise. However, Figure 5B shows significant autocorrelation(s) in the same series even after 20 lags. Finally, Figure 5C, a plot of cumulative Z score versus time, shows a definite cycle in the data with a period of approximately 450-500 readings. Note that no replicable frequencies characteristic of the organism or its environment (other than the diurnal or circadian) have been found.

D. Trends and periodicity - combinations of repeating cycles with consistently increasing or decreasing average velocity readings. Figure 6A shows both trend (increasing) and cycles in a sample of over 1300 baseline readings. Also, Figure 6B shows significant autocorrelations through 50 lags for the same series, with some slight periodicity visually apparent in the correlogram itself.

E. Mean Shift - an obvious and relatively abrupt shift in the average velocity. This characteristic may be a "discontinuity" in an apparent long range trend and may or may not include periodicity. An example is shown in Figure 7.

General Observations of Baseline Data

- All of above, items A thru E, exist, or can exist in the data stream at any given time.
- Existence of one or more of these phenomena can only be determined after the fact, i.e., after the data have been collected and analyzed.
- No a priori adjustment of data to "compensate" for these phenomena is conceivable. They must all be treated as inherent properties of the "baseline".
- Statistical treatment of the data, e.g., to test the null hypothesis of no psi, must be "robust" enough to cope with these issues.

FIGURE 3

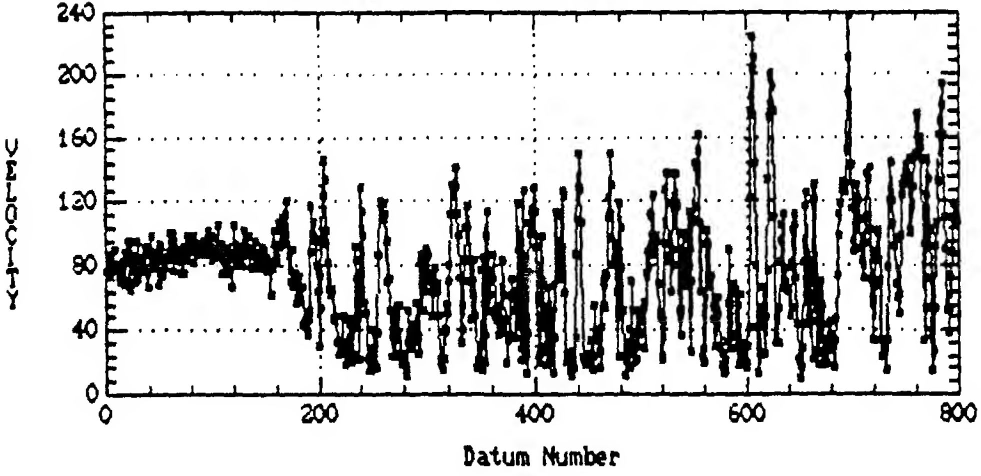

Baseline Data - (Averages of 10)
VELOCITY
240
200
160
120
80
40
0
0
200
400
600
800
Datum Number

FIGURE 4A
Baseline Data

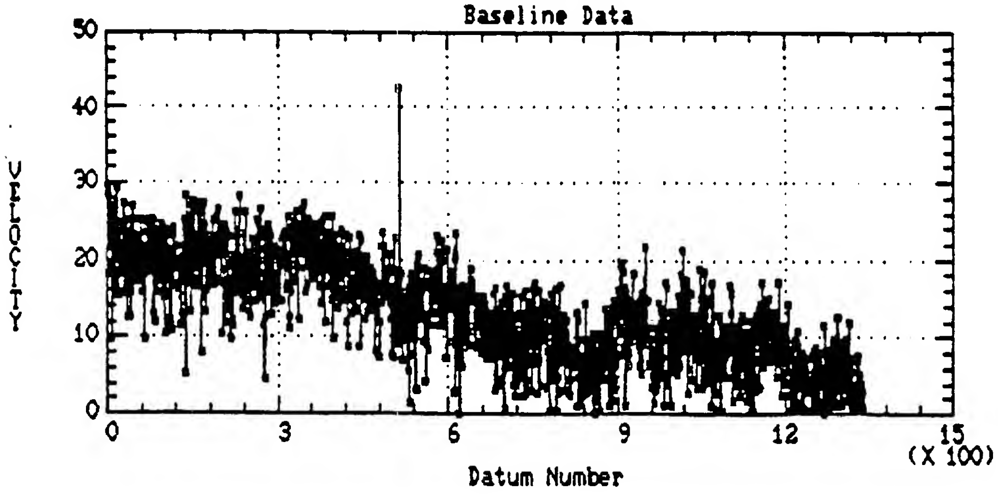


FIGURE 4B
Baseline Data - (Averages of 10)

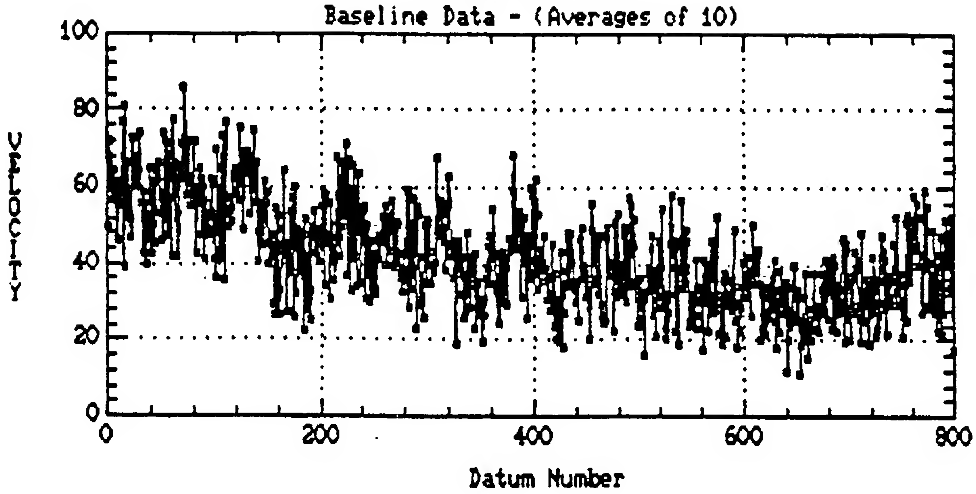


FIGURE 5A
Baseline Data

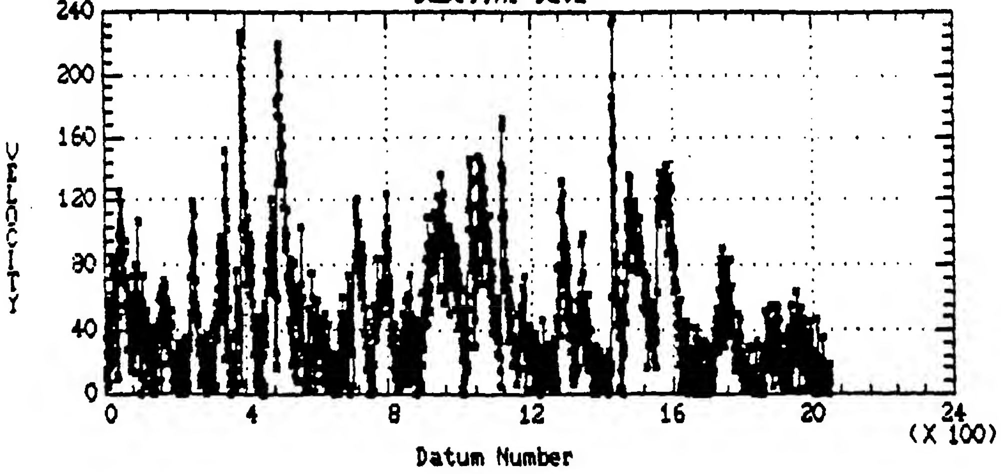


FIGURE 5B - Baseline Data
Estimated Autocorrelations of Velocity

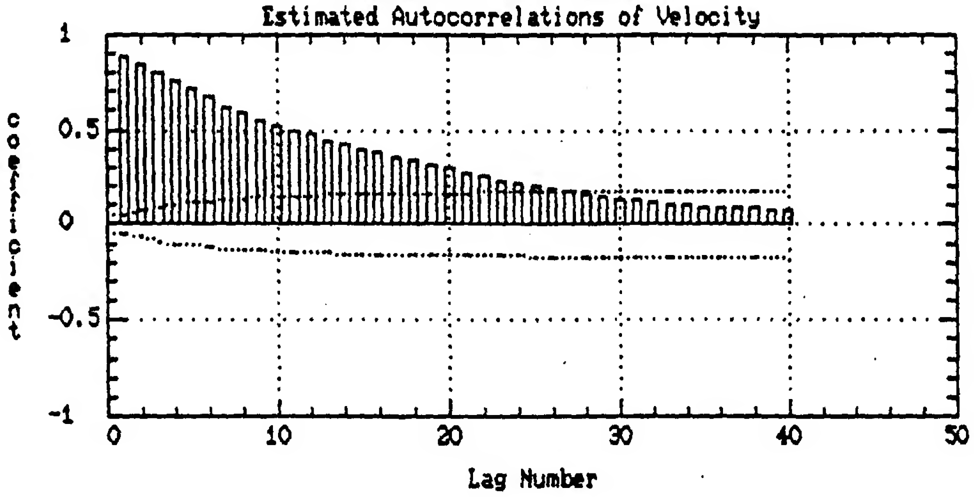


FIGURE 5C - Baseline Data
Cumulative Z Score from Velocity

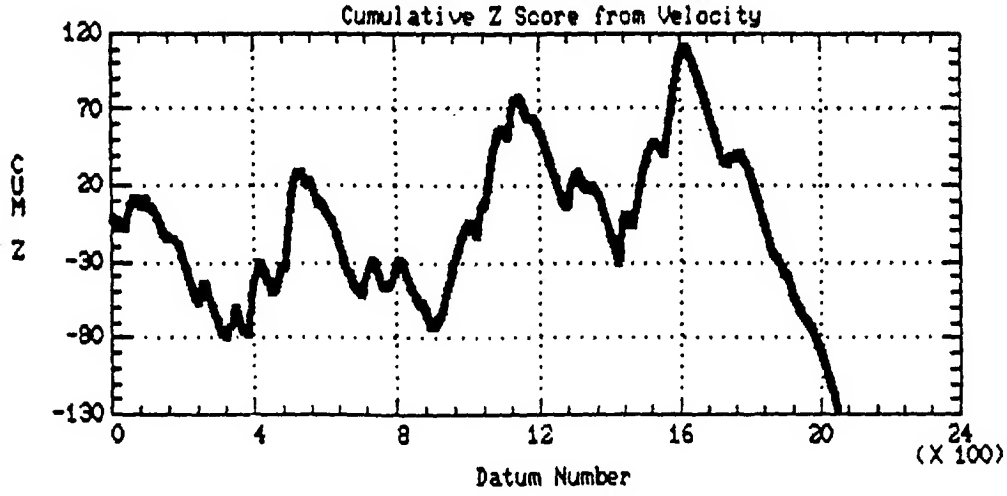


FIGURE 6A
Baseline Data

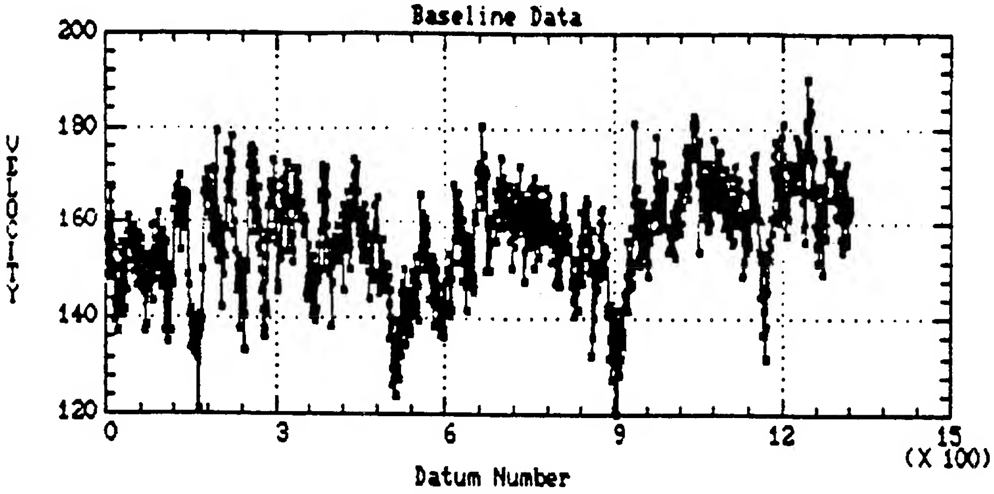


FIGURE 6B - Baseline Data
Estimated Autocorrelations of Velocity

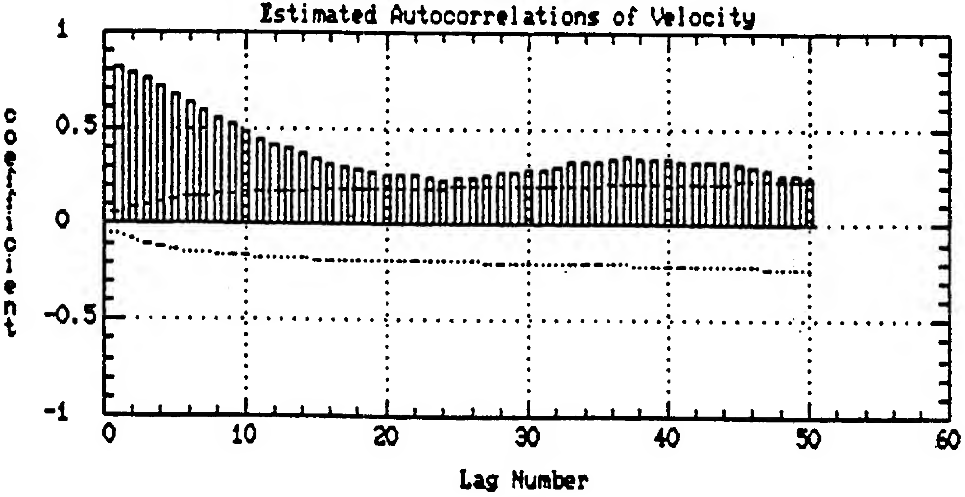
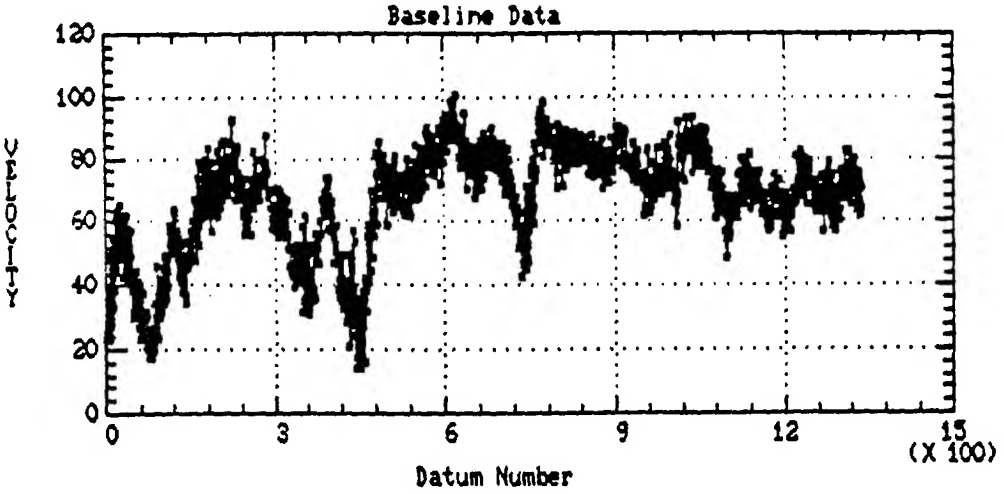


FIGURE 7
Baseline Data



- All of the above points argue for the use of "global" comparisons and relatively large sample sizes to provide meaningful statistical tests of the null hypothesis.

Statistical Analyses

Two experiments known as PK85 and Wave will be discussed. Both involve marking the ongoing data string in similar formats, illustrated in Figure 8, using preprogrammed keys on the computer keyboard. The psi interval is followed immediately by a control interval of the same length. After a pause of random duration, pseudo psi and pseudo control intervals which have identical dimensions to the real run are automatically marked in the data file. In each analysis the null hypothesis was that there was no psi effect extant, and the data were detrended by using the double difference

$$\Sigma(\bar{X}_{control} - \bar{X}_{psi}) - \Sigma(\bar{X}_{pseudocontrol} - \bar{X}_{pseudopsi})$$

as the score for the run.

PK85

Additional details of the PK85 protocol are given in Pleass and Dey (1985). The participants were asked to try to visualize the algae in the vicinity of the laser crossover during the psi period using informal, light-hearted imagery, while excluding all unrelated conscious thoughts. The initial procedure required ten runs to complete a set. The random interval (Figure 8A) was limited to a maximum of up to 5000 raw data points. After one run cycle was completed, a symbol would appear in the bottom left corner of the monitor, indicating that another run could be initiated whenever the participant elected.

The time required to complete a set of ten runs was 1.5 - 2 hours. The participants soon learned that selecting the shortest psi period possible would shorten the length of the set. Typical psi intervals ranged from 30 seconds to 2 minutes. After discussions with participants the number of runs in a set was reduced to five, which could be completed in approximately one hour. This helped to eliminate the "mid-set blues": the feeling that there were still many more runs to do.

The statistics routinely calculated were the differences in the means and standard deviations. The results were presented to the participant at the conclusion of each set, and saved to file with the raw data. To accumulate from set to set scores were calculated for each run from the double difference (mean control - mean psi) - (mean pseudocontrol - mean pseudopsi) and these scores were developed into histograms with the best fitting Gaussian overlaid. Figure 9 reports the results of 22 sets, treated as 205 runs.

A significant step forward occurred when the results of these experiments were compared to results artificially generated from data collected when no psi experiments were in process. In this additional level of control, which will be referred to as "global control", the data file dimensions of the sequence psi/control/spacer/pseudo-psi/pseudo-control were taken from the markers identifying the real psi experiment data string and transferred to data taken without psi intent, either before or after the set. Note that although overnight data were available, we chose not to use these for global control

Figure 8

PK85 and Wave Procedures

Null hypothesis: no significant difference between

$$\Sigma\ (S_{control} - S_{psi}) - \Sigma\ (S_{pseudocontrol} - S_{pseudopsi})$$

where S is any statistic such as the mean

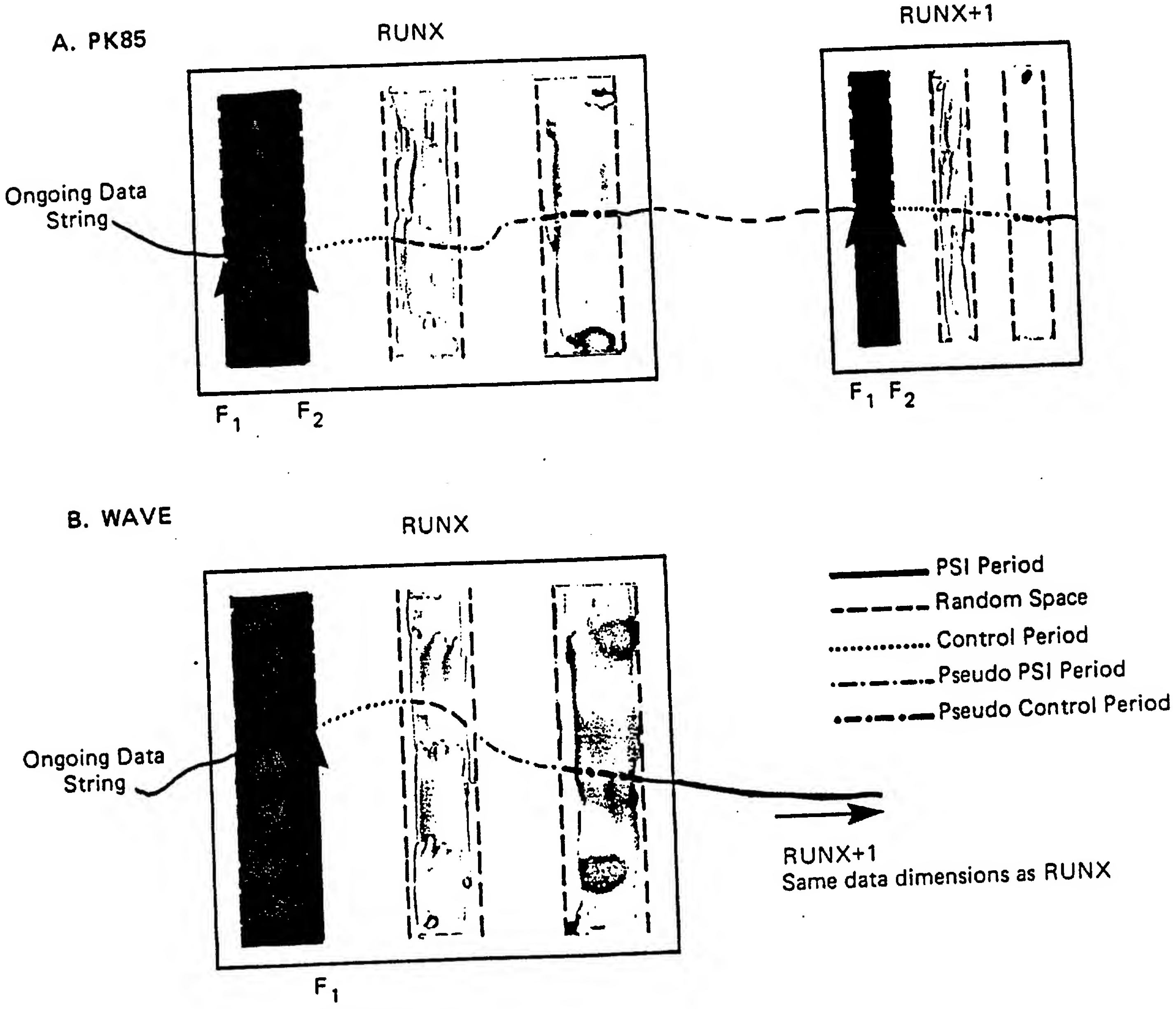


FIGURE 9: PX85 Experiment Results
205 Runs

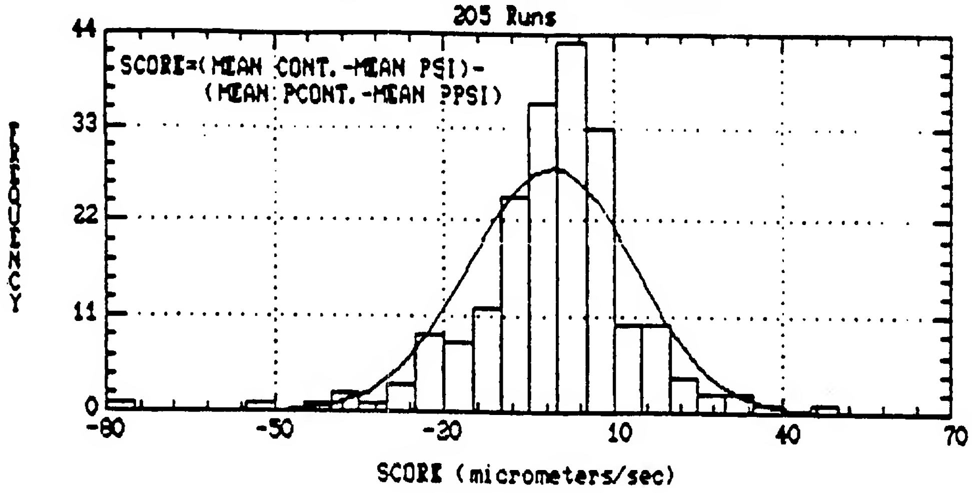
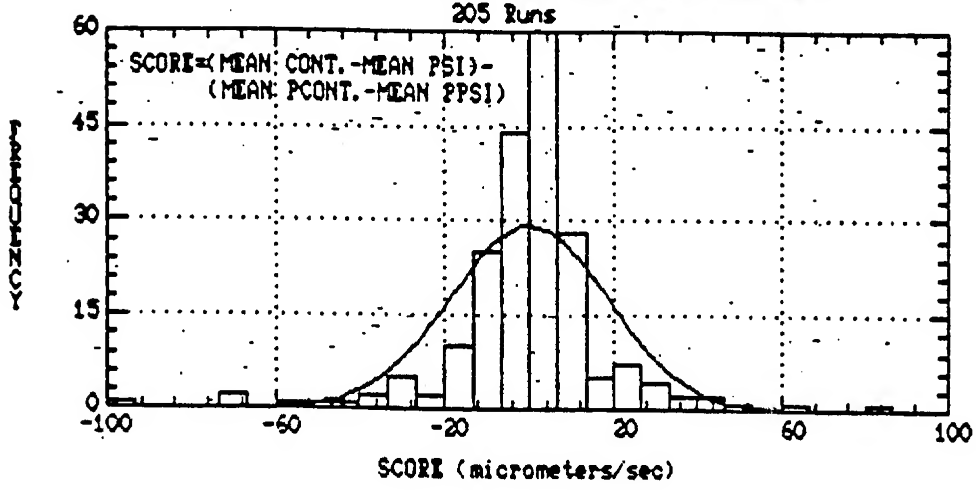


FIGURE 10: Global PX85 Experiment Results
205 Runs



since the circadian phase angle differs so much from that extant during the sets, which were carried out during the day. Figure 10 illustrates the global control "scores".

To develop a probability value we compared the best fit Gaussians representing the scores from the real experiment with the global control, using an F test.

$$\frac{\sigma^2 \text{global}}{\sigma^2 \text{psi}} = 1.64$$

With 204 degrees of freedom this gave a probability of a chance difference less than 2×10^{-4}, suggesting that the null hypothesis should be rejected.

WAVE

This modification to the PK85 protocol was a consequence of discussions with our participants during the informal debriefing period which normally followed each session. It is illustrated in Figure 8B. In it the participant was asked to begin his psi effort at his own pace, at any time after the computer signaled its readiness to accept another run. This warm-up and psi period had no set length; indeed participants often took several minutes warming up to their psi effort. We asked them to touch the F1 key on the computer keyboard when they felt their psi effort was at a strong peak, and to immediately turn away to the trivial control period task. Reading a dictionary was found to be an effective way of quickly transferring attention. In this way, we hoped to observe the release of psi pressure. It was suggested that the movement to press the F1 key be a response to a subconscious cue, and none found this difficult. Once the F1 key was pressed, the monitor screen was turned blue during collection of the control, the spacer segment, the pseudo-psi and the pseudo-control data. At the conclusion of this period, the monitor screen turned grey, signaling readiness for another run. The peak psi period was taken to be the 25 data records (2500 raw data points) preceding the F1 keypress; thus all Wave runs have the same data dimensions. As usual, the control, pseudo-psi and pseudo-control all had the same dimension as the psi. We continued to use the same null hypothesis, algorithm, and format for feedback.

Initially, participants were asked to complete ten runs for each set during one visit to the laboratory. This took nearly two hours, due to the manner in which most participants chose to undertake their psi effort. As a consequence, the required effort for a set was shortened to five runs per set. Preliminary analysis of this data was conducted at the conclusion of each set, and graphical displays of differences in means were provided as feedback, just as in PK85.

Quite striking results were obtained from indiviudal sets (Pleass and Dey 1985). Run scores were then compared with global controls. Figures 11 and 12 show the data, with best fit Gaussians. In this case the experimental results have a much larger range than the global results:

$$F = \frac{\sigma^2 \text{psi}}{\sigma^2 \text{global}} = 5.99$$

FIGURE 11: WAVE Experiment Results
293 Runs

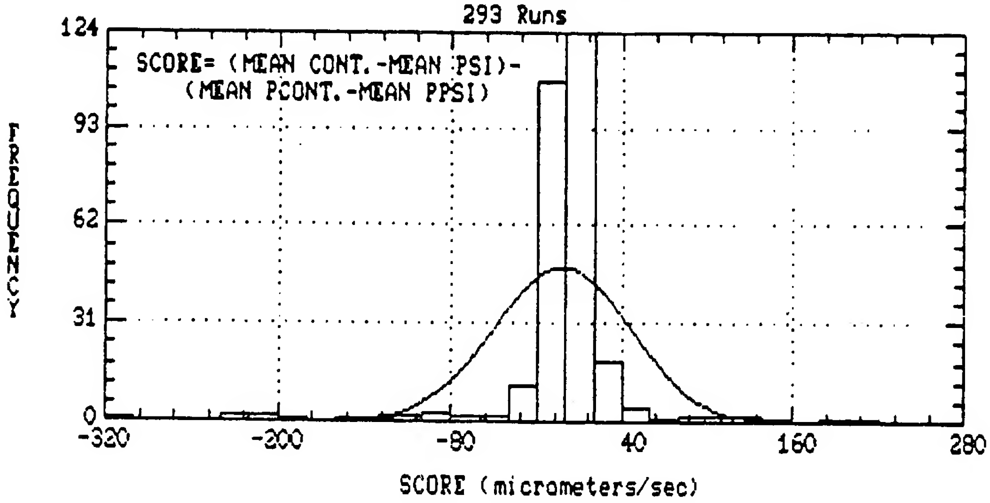
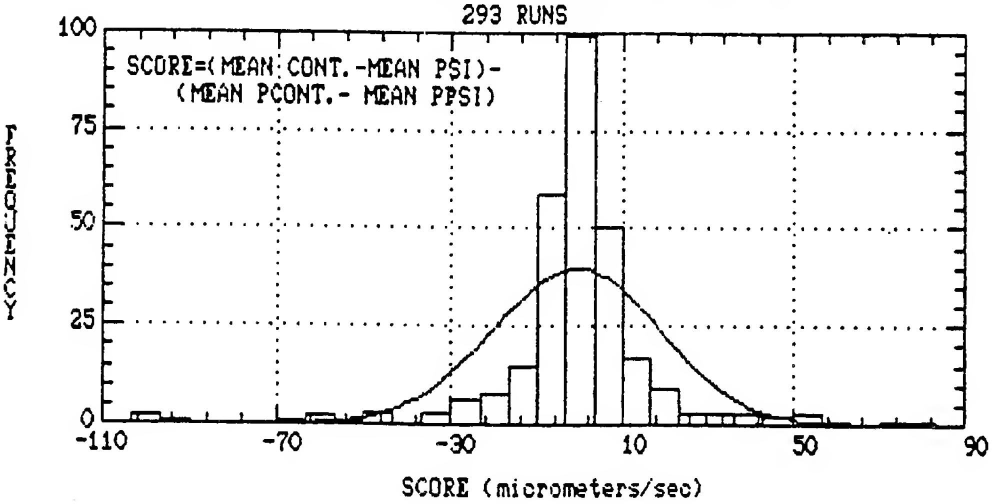


FIGURE 12: Global WAVE Experiment Results
293 RUNS



The probability of obtaining the result by chance is very low, $p = 10^{-6}$, again suggesting that the null hypothesis should be rejected.

It is appropriate to ask if the two "global control" distributions are similar, within experimental error, since the sample numbers are quite high, and it would be difficult to explain any difference. Applying an F test to them we find

$$F = \frac{\sigma^2 \text{Wave global control}}{\sigma^2 \text{PK85 global control}} = 1.11$$

$$p = 0.2$$

This gives us substantial confidence in the chosen procedures.

DISCUSSION

Since PK85 and Wave differ substantially in "feel" and in the method of defining the psi and control periods, the inversion in the F ratios is not unreasonable. There is also evidence that some participants have a general tendency to reduce mean velocities and biological "noise", while others enhance these data properties. Only three participants contributed to the PK85 data shown, with a run ratio of 20:1:1, and it may be that the data reflects one persons "signature". In contrast, fourteen participants contributed more evenly to the Wave data. As our data base expands, we hope to obtain a better understanding of participant-related variables.

It is appropriate to use the most cautious interpretation of the results: the physics of the method used in the research is straightforward, but it is conceivable that there are alternate explanations for the differences between experimental and global data, since the global data cannot, by definition, be taken at the same time. The only method which can be used to obtain global data at exactly the same circadian phase angle is to take it from a different diurnal period. This possibility will be examined.

The insignificant difference between the distributions of global control data from the two experiments ($p = 0.2$) helps to validate the statistical procedures. However, it is reasonable to question the use of the F test, since the histograms of scores contain several extreme values. This test is used in an exploratory mode, for want of a better method of describing the differences between the two data sets. Suggestions for alternate methods of statistical processing would be most welcome.

CONCLUSIONS

Two statistical analyses of psi runs carried out with the green alga Dunaliella have been reported. They examine the significance of changes in psi and control period statistics, derived from strings of velocity data. Taken at face value, the results suggest the rejection of the null hypothesis that there is no psi effect. However, this is the first experiment of this type to be attempted, and the results should be treated with caution until they are substantiated by further research and various alternate statistical treatments.

ACKNOWLEDGEMENTS

The consistent support of the McDonnell Foundation has enabled this work. We would also like to thank our colleagues at the Princeton School of Engineering and Applied Science for continued inspiration, and many excellent ideas, and Ms. Anju Joglekar, Ms. Lisa Knight, and Mr. Gary Defibaugh for their assistance with the analytical work.

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Appendix 1

TARGET SYSTEM AND DATA SECURITY

The lab building

Chosen to be free from extraneous vibration and electrical noise, the lab is located on a sand dune known as Beach Plum Island, adjacent to the CMS campus at Lewes, Delaware. To access the lab one must cross the Broadkill River in a small boat. There are no other projects ongoing in the lab.

The laser room

- The culture of Dunaliella, the laser, and the transmitting and receiving optics are all mounted on a vibration isolation table in a very heavily insulated room. Quantitative data describing the residual vibrations on the table under the conditions of the experiment were obtained using an integrating FFT oscilloscope. When compared to similar FFT's of the Doppler shifts from a culture of Dunaliella on the same table (Figure A-1) it is evident that the vibration isolation is effective.

- There are no motors or lights other than the laser in the room with the subject culture. The laser power supply, the tracking electronics and the PC are in the adjacent room.

- The thermal insulation makes the room almost soundproof. Wind noise outside the building is totally imperceptible. The laser tube is a minor heat source, and to ensure a constant temperature at the culture vessel the room is cooled by water from dedicated wells, circulated through the room and returned to the aquifer under the lab. This avoids the problems of sound, e.m. field, and air turbulence associated with air conditioning. The temperature of the well water may change by 5°C over the year, but no change is detectable over the period of a run. Room temperature is routinely recorded.

- The door to the laser room was barred by a thick sheet of urethane foam insulation, which was pressed into place in the early morning immediately after the culture had been changed. The participant could not remove this without being observed by the experimenter.

The participant's room

- This adjoins the laser room. The participant may close the door, isolating themselves visually from the experimenter. Until 1986 there were a number of things which a dishonest participant might have tried to do in an attempt to create an artifically high score:

  1) Knock (vigorously) on the wall between the two rooms during either the psi or control period. However, this would be clearly audible to the experimenter.

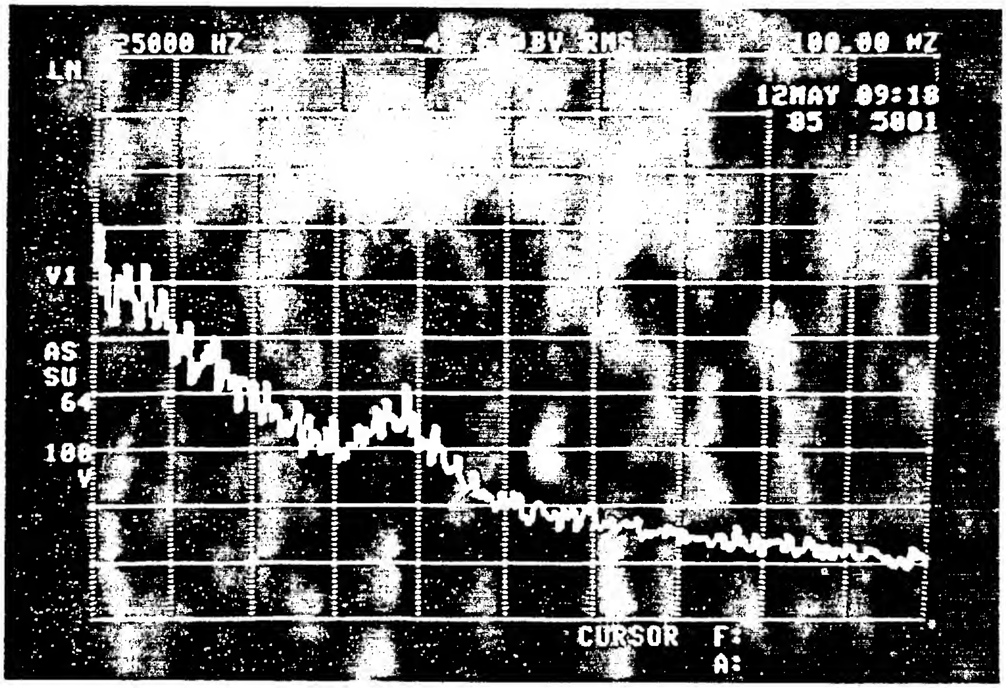
2) "Play" with the knobs on the electronics adjacent to the computer keyboard. This would normally throw the equipment out of lock, causing the data string to terminate. If by some remote chance it did not, the data might show a sudden mean shift. However, the probability of a participant being able to repeat this without losing control is virtually zero. Since the experiment appears to have potential, we have now (1986) placed all the electronics in a glass fronted locked cabinet.

3) "Play" with the computer keyboard. Nothing the participant could do at the keyboard could give them access to the data or cause any change in the evolving data string. Feedback was after the conclusion of the set.

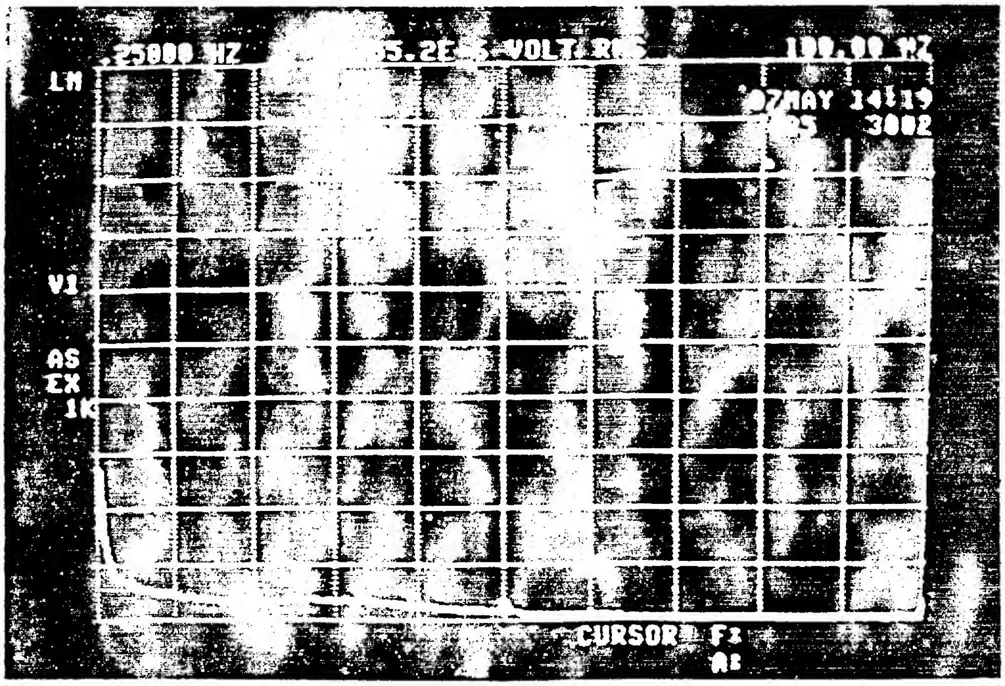
The participants

- No participants professed any psychic ability. Some were from the University community, and some were interested Lewes residents. The male/female mix was approximately even.
- Each participant was allowed to study algae swimming in a haemocytometer prior to their set, to help with visualization. This was done in a separate room. None could have predicted changes in algal velocities based on this preview. Only a few alga are visible in the microscope field, and their behavior there will be dominated by the effect of the high intensity white light of the microscope.

Figure A-1



Live Dunaliella



Vibration on pedestal