Event-Related Brain Potentials and a Phenomenological Model of Psi-Conducive States

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ABSTRACT

A high-scoring subject (S) identified three altered states of consciousness associated with psi. Through the process of participant observation, a description of these states was elaborated which was similar to Carl Jung's writings on the psychological aspects of medieval alchemy. Two experiments were performed to investigate the event-related brain potentials (ERPs) associated with this phenomenological model and an objective, clairvoyant task. In the first experiment (State Study), ERPs were recorded while S cycled repeatedly through these three states and a control condition. In the second experiment (Prediction Task), ERPs were recorded during a forced-choice, five-response, clairvoyant task. In both experiments, ERPs were recorded over an 8000 msec interval prior to each S response from 5 EEG channels, one EOG channel and one EMG channel. In the time domain, mean inter-channel correlations of DC and slow wave activity were higher for correctly guessed (RTE) (.89) than for incorrectly guessed (WRO) (-.02) trials. Inter-channel correlations of DC and slow waves during the most psi-conducive states were found to be most similar to RTE trials, while WRO trials were most similar to the least psi-conducive states. In the frequency domain, offline analyses of single channels using Bonfonerri-corrected t-tests on fast Fourier transforms (FFTs) of the ERP data revealed sets of frequency values which distinguished the most psi-conducive state from the least, and RTE from WRO guesses. Stepwise discriminant analyses (SDA) of ERP RTE/WRO data revealed sets of frequency values which correctly classified psi RTEs from WROs, when applied to independent data samples, at above-chance levels (maximum 78%, $p < .001$). A discriminant model developed on the State data (most psi-conducive/least psi-conducive state) and applied to data from the clairvoyant Prediction task, correctly classified RTEs/WROs at above-chance levels (maximum 67%, $p < .001$). Differences in DC effects, results of t-tests of the frequency spectra, SDA classifications of subjective states and performance--all lent support to the phenomenological model.

INTRODUCTION

The purposes of this single-subject study were: First, to record brain wave data from several increasingly psi-conducive altered states of consciousness (State Study), and a forced-choice, five-response, clairvoyant task (Prediction Study). Secondly, to perform analyses in the time and frequency domains in order to discriminate RTE from WRO guesses and the various states of consciousness. Thirdly, to cross-validate predictive models on additional, independent RTE and WRO trials. Elaboration of the altered states description was derived from participant observation (Spradley, 1980) of a subject (S) who had performed above chance levels in previous psi tasks (Warren & Don, 1986). The latter report by Warren and Don presented evidence that both time and frequency domain ERP data could be used to significantly discriminate RTE from WRO trials in a clairvoyant task. The present study repeated this and also studied the self-reported altered states of conscious of S and the ERP relationship between altered states and clairvoyant performance.

During extensive participant observation of S, a phenomenological description of the S's inner experience gradually emerged. Over the course of three months of interviews, conducted twice weekly, a description was developed which strongly paralleled Carl Jung's writings on the psychological aspects of medieval alchemy (Jung, 1953). The S claimed not to be acquainted with these writings nor was he educated or interested in psychological topics. Neither did he describe his inner experience in terms which would lead one to think quickly of Jung's writings on alchemy. Rather, this picture slowly emerged over the course of the interviews, which were video taped. During these interviews, the S attempted to teach one of the experimenters (E1) how to perform some clairvoyant tasks. E1 interacted extensively with S during these sessions, in a manner which is only possible in the participant-observer modality. In this way, there was an unfolding of the S's experience which is very characteristic of this type of process. This often leads to a deeper understanding of the S's inner experiences since it is conveyed to the interviewer in the S's own terms and in an interactive manner, rather than in a purely observational manner, structured according to the observer's preconceptions.

The picture that emerged was of a spectrum of states of consciousness which matched Jung's writings on alchemy. The S described three points on this spectrum as Condition One (CD1), Condition Two (CD2) and Condition Three (CD3). Very briefly, Condition One was the most primitive altered state of consciousness; it was described as being "black" and with little or no potential for psychic functioning. This appeared to be the nigredo of alchemy, the "black blacker than black" (Jung, 1953,

p. 313). Condition Two seemed to correspond to the alchemic state called the "yellowing," (xanthosis) in which, according to S, some limited psychic work is possible. At the end of the spectrum lay Condition Three, the prime psychic state, the threshold of which being the "white light," which appeared to correspond to the leukosis. Again, this description of the S's conscious experience was not native to the S; at no time did S use the terminology of alchemy or Jung's writings, referring to these states merely as Condition One, Two and Three.

S had referred frequently to the three Conditions. Therefore, an experiment was undertaken to investigate the brain wave characteristics of these states. Although much event-related brain potential (ERP) research has been done over the past 20 years using a variety of cognitive tasks, the use of ERPs in the investigation of clairvoyance has been extremely limited. The term ERP is here defined broadly as that transient brain electrical activity which occurs in relation to specific events--either in response to external events, endogenous events or overt motor behavior. This ERP activity may be expressed either in the time or frequency domain. A small number of studies have been published over the past 15 years in which limited frequency band activity has been related to a clairvoyant state. Alpha activity (8 - 12.9 Hz), usually in the occipital region, has most often been identified with psi states (Kelly, 1977; Morris et al., 1972; Stanford & Stevenson, 1972; Stanford, 1971; Honorton et al., 1971; Honorton & Carbone, 1971; Stanford & Lovin, 1970; Honorton, 1969). One general problem with the foregoing studies is their preoccupation with the alpha band; other frequency bands are given short shrift or are ignored completely. Moreover, none of these psi studies examined changes in ERP activity over the time domain. An exception is Hartwell (1979), who studied the Contingent Negative Variation (CNV) during performance of a psi task.

We presented an ERP study of clairvoyant states at last year's conference (Warren and Don, 1986), which, contrary to Hartwell's study, did yield positive results. One reason we feel we achieved successful ERP discrimination of RTE from WRO trials was due to our use of a S who could consistently attain high scores on the task. This permitted us to develop robust discriminant models which we could cross validate. We are aware that single-subject experiments with high-scoring persons pose unusual problems of security and generalization of findings. In this case the major experimental purpose was not to validate exhaustively or invalidate such a S's ability. Rather, our goal was to study brain wave indices of cognitive states associated with high-accuracy judgmental performance, and to determine similarities and differences between State and Prediction tasks. The apparent S performance level reduced the problems of data collection and statistical modeling to manageable proportions. We have relied upon ERP methodology both to study the scientific

issues posed and to establish the groundwork for the discrimination of veridical psi from fraud. What security measures we took we felt were adequate; however, we recognize clearly that in a traditional psi experiment with the same targets, far more elaborate security would be indicated. We refer the reader to the two final paragraphs of the discussion section of this paper, which return to this issue from the perspective of the experimental findings.

METHODOLOGY

Procedure

Brain wave data were collected from two sets of experiments. The first (State Study) aimed at studying the brain waves during CD1, CD2, CD3 and a control condition. The second set (Prediction Study) involved a forced-choice, five response, clairvoyant task during which brain wave data were also collected.

Subjects All measurements were made on one right-handed S with a reputation for achieving high scores on Zener card tasks.

Experiment One: Study of States of Consciousness (State Study) In this experimental/phenomenological section of the study S repeatedly cycled through the three self-identified altered states plus a control condition. S initiated the beginning of a new trial each time he entered a new Condition, (in his subjective opinion), by pressing the trial initiate button. At the end of eight to 12 secs (self-paced) he pressed the termination button. He then announced how well he had achieved that particular state of consciousness by rating his subjective experience on a six-point scale, from poor to excellent.

Three hundred fifty-six artifact-free trials of State data were collected. The instrumentation and data processing procedures were identical with those described in Experiment Two, below, except where noted.

Experiment Two: Forced-Choice, Five-Response, Clairvoyant Prediction (Prediction Task)

Target Preparation A person (Target Preparer 1 - TP1) affiliated with the laboratory but not involved in the present experiments was given 100 Zener cards (20 of each symbol) and was instructed to affix two layers of blank, white, adhesive labels over the symbol side of each card. The labels were opaque and the adhesive was such that the labels would not neatly peel off;

therefore, any attempt to remove the labels caused obvious tearing of the labels and permanent alteration of appearance of the outer surface of the cards. TP1 then affixed a small, adhesive tab on the back side of each card. All cards were placed in a paper bag, shaken vigorously, then were withdrawn one card at a time from the bag. As each card was withdrawn, it was numbered sequentially, starting with number one. Target preparation occurred one week prior to S returning to the laboratory site from his city of residence, a distance of some 2000 miles. TP1 performed the preparation in her private office with no other people present. TP1 then immediately gave the targets to E1 who placed them in an envelope which he put in the inside, breast pocket of his suit jacket. Some four hours later, immediately upon returning to his residence, E1 placed the targets in a locked filing cabinet located within a locked closet (high-security lock) until the experiment was performed the following week. At no time was S in possession of the stimuli.

Random Number List Preparation Prior to the experiment, a list of 100 unique random numbers (1 - 100) was generated from a computer program embodying a pseudo random number generator; these numbers were used to select the targets during the experiment. The computer program was seeded using the random number function on a calculator.

Testing Protocol Similar to Warren and Don (1986), electrodes were applied to S in the subject chamber. Throughout the experiment, S remained in the subject chamber, a room adjacent to the computer room. He was seated in a high-back recliner chair and had a heavy, black, wooden, performance platform placed across his lap, which attached to the arms of the chair. This effectively prevented him from rising from his chair or turning around. One meter in front of S was a parabolic, flat-black, construction-board barrier. S's right hand rested at the base of the manipulandum, a numeric calculator key pad mounted on a base. The S's index and middle fingers rested on the two keys; movement of the hand was unnecessary.

During the session one of the experimenters (E1) was present in the subject chamber with S. E1 stood behind and to the left of the subject chair in order to place the targets, as indicated by the random number list, on top of the S's left hand, which was immobile throughout the experiment. Between trials, E1 consulted the number list to determine the next stimulus presentation. The entire list was subject to E1's gaze. S was not permitted or able to look at the list; viewing the list would not have aided him in guessing the targets since it contained only sequence information. During the session, S was unable to see the list because of his seated, locked-in position, and because of the absence of reflective surfaces in the room. Also, any attempt on S's part to view the list would have resulted in significant

movement artifacts in the EEG which would have excluded that trial from further analysis. The cycle for each trial was as follows: (1) E1 initiated trial by placing a target indicated by random number list on top of S's left hand for 10 seconds (back of card toward S); (2) E1 removed envelope; (3) S then pressed the trial start button; (4) S waited from 10 to 12 seconds (self-paced) before pressing the trial termination button on the manipulandum; (5) S announced his guess; (6) S was allowed to blink and move his eyes. Note that no trial-to-trial or outcome feedback was ever given to S during the experiment. E1 waited more than two seconds before presenting the next target. One hundred twenty trials were run; session length was about 45 minutes.

EEG Recording Sensormedics Corporation, sintered, non-polarizing, silver/silver-chloride electrodes were applied with adhesive electrode collars and surgical mastic. Beckman electrolyte gel was used to establish electrical contact between the surface of the scalp and other head surfaces and the electrodes, which were placed at Fz, C3, Pz, C4, and Oz (International 10/20 system) referred to linked ears. In Experiment One, the State Study, and session 1 of the Prediction Study, instead of the Oz placement there was a bipolar Fpz-Oz derivation. EOGs, used to detect eye-movement artifacts, were recorded as the potential difference between electrodes placed above and to the right side of the right eye. A forehead ground was used. EMGs, used to detect the presence of muscle artifacts, were recorded. Three EMG electrode placements were used: (1) frontalis muscle, (2) digastric muscle (under the chin); these were linked and referred to (3) the right mastoid process. An AC amplifier integrated these signals; trials indicating EMG activity were excluded from further analysis. Electrode impedances were below 5 K ohms; Grass model 7P122 amplifiers with 8-second time constants were used in a Grass Model 78 polygraph. On the EMG channel only, the time constant was 0.2 secs. The one-half amplitude high frequency cut-off was set at 60 Hz on the EEG and EOG channels and 75 Hz on the EMG channel. A 60 Hz notch filter was used on the EEG amplifiers. One hundred microvolt pulses were recorded before the experiment in order to calibrate each channel.

Data were displayed real-time on the polygraph strip chart recorder and were simultaneously recorded on a Vetter FM tape recorder for off-line analysis. An eighth channel was used as an event channel to record the onset of each button press indicating start and termination of each trial.

Data Analysis

The EEG data plus the EOG, EMG and event channel were digitized at 125 samples/sec (8 msec per datum) on a Digital Equipment Corporation PDP-11/03 computer. A trial consisted of 8000 msec of data (1000 data points) per channel. In the State Study (Experiment One) each trial consisted of 1000 data points

per channel while S was in one of the identified Conditions. In the Prediction Study, Experiment Two, each trial consisted of 1000 data points per channel while guessing the card symbol. In both experiments eight 128-point FFTs were calculated for each data channel (average overlap of 3.5 data points per FFT), windowed with a split-cosine bell; the frequency range was 0 to 62.50 Hz with resolution of 0.977 Hz. Additionally, files of time-domain data were stored.

A total of 120 card-guessing (Prediction) trials and 405 State trials were collected and extensively edited by computer and visual inspection in order to exclude trials contaminated by artifacts due to eye blinks and movements, as well as instances of excessive electrode drift and EMG activity. Exclusion of EOG contaminated trials was necessary since large amplitude EOG signals masked EEG signals. EMG activity overlapped the higher EEG frequencies and thus necessitated exclusion of those trials. A total of 356 State and 96 Prediction trials were collected which were artifact free.

Artifact-free single trials were baseline subtracted and then averaged--yielding average time-domain waveforms for each State condition and Prediction Task accuracy level (RTE/WRO) with equal initial DC levels. One thousand data points per channel were reduced to 10 voltage values by averaging successive 100 point (800 msec) segments. This served as a linear filter, removing fast EEG activity from the waveforms leaving only DC and slow waves (-3 dB equivalent cut-off frequency at 0.35 Hz). Pearson product-moment correlation coefficients were computed on the segment data between all pairs of electrode locations within each averaged waveform. Channel Oz was excluded from waveform analyses since it was recorded differently in separate sessions (monopolar vs. bipolar). Correlation coefficients were compared between conditions using matched sample, two-tailed, t-tests with 12 observations per test (6 inter-channel correlations for each of two conditions) and 5 degrees of freedom.

All spectral data from the State and Prediction Study were placed in a computer (IBM PC AT) data base (Foxbase +, 1986). The data base was used only to perform the paired t -tests cited below.

FFTs were analyzed by Stepwise Discriminant Analysis (SDA or SD analysis) (Dixon, 1971; 1985). The SDA developed a pair of linear equations which utilized the brain data of a given channel to maximally predict right (RTE) and wrong (WRO) subject judgments. The equation yielding the highest score determined the classification. Thus, if the RTE equation yielded a larger score than the WRO equation the trial was classified as a RTE trial. The accuracy of these equations in correctly classifying subject judgments will be referred to as the performance or classification accuracy (CA) of the SDA.

RESULTS

I. Time Domain

Table 1 shows inter-channel correlation coefficients and means for each State condition and for RTE and WRO trials in the Prediction Task. Figure 1 depicts inter-channel correlations (two top-of-head views) for RTE trials and for WRO trials. Mean inter-channel correlations were .89 for RTE and -.02 for WRO. As seen in Table 1A, this difference was statistically significant ($p=.013$, two-tail; exact probabilities are reported in this and the ensuing paragraph). However, because RTE trials outnumbered WRO trials, and may therefore have benefitted by a greater signal to noise ratio, it was reasoned that the higher inter-channel correlations observed in RTE than WRO averages might have simply reflected differences in the numbers of single trials entering each average. To test this possibility, seven additional averaged waveforms were created from sets of single trials ranging from 10 to 70 in number. Each of these averages consisted of roughly equivalent proportions of RTE (2/3) and WRO (1/3) trials selected pseudo-randomly from the pool of artifact-free Prediction Task trials. Mean inter-channel correlations computed from these averages are plotted in Figure 1A, and show no apparent direct relationship to the number of trials comprising each average.

T-tests were also performed on the correlation data between each of the State conditions and RTE/WRO trials from the Prediction Task. The results shown in Tables 1 and 1A indicate that mean inter-channel correlation was higher for CD3 (.93) than WRO (-.02) trials ($p=.015$) but not different for CD3 and RTE (.89) trials ($p=.354$). Mean inter-channel correlations also tended to be higher for CD2 (.76) than WRO ($p=.063$), but not different for CD1 (.69) and WRO ($p=.229$), or for CD7 (.22) and WRO ($p=.666$). On the other hand, correlations were significantly lower in CD7 than RTE ($p=.007$) and were marginally lower in CD2 than RTE ($p=.059$), and in CD1 than RTE ($p=.098$). Non-significant p-values indicate non-significant differences, hence similarity among pairs of variables, e.g., $p=.354$, CD3/RTE. The analyses in Table 1A tend to support the Condition/Prediction models similarity.

The voltages upon which the above correlations were computed were also averaged in 10 segments of 100 points (800 msecs per segment) per channel. The bandpass for this linear filter was 0 - 0.35 Hz; 10 average voltages for each channel Fz, C3, Pz and C4 were computed. Grand averages were then computed across the four channels for each of the 10 segments for WRO and RTE trials. Inspection of the 10 grand averages for the RTE and WRO trials

suggested that during at least the first 4000 msec before the terminal button press (at 8000 msec), the average RTE voltages were greater than the average WRO voltages. This suggested a differential positive voltage bias for RTE compared to WRO trials ($t = 2.866$, p approximately .02 two-tailed, $df = 8$). Also, several interesting trends in the negativity of these averages were noted qualitatively prior to the terminal button press, but were not examined in detail.

Table 1: INTER-CHANNEL, PEARSON PRODUCT-MOMENT CORRELATIONS

Conditions or Task Accuracy Correlated	Channel Pairs						
	Fz-C3	Fz-Pz	Fz-C4	C3-Pz	C3-C4	Pz-C4	Mean*
CD1	.98	-.07	.82	.03	.91	.21	.69
CD2	.96	.55	.73	.47	.59	.85	.76
CD3	.93	.78	.97	.90	.98	.88	.93
WRO	-.53	.77	.47	-.37	-.79	.38	-.02
CD7	.66	-.62	.82	.08	.50	-.45	.22
RTE	.97	.91	.89	.83	.89	.76	.89

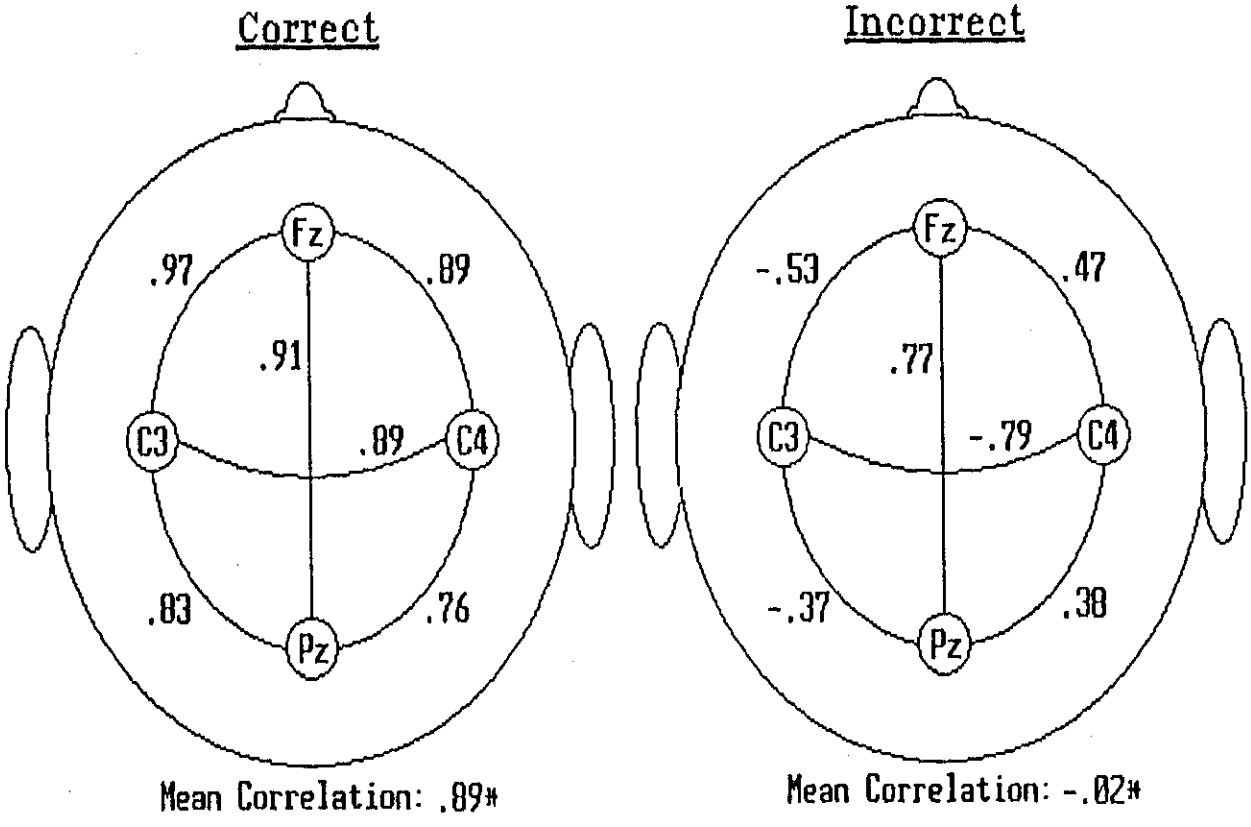
* Means were computed by applying the Fisher Z transform to the Pearson product-moment correlations, averaging, then inverse-transforming the mean Fisher Zs to mean Pearsons.

Table 1A: MATCHED-SAMPLE t-TESTS

Comparisons	t *	p
CD3 vs. RTE	1.02	.354
CD2 vs. RTE	-2.43	.059
CD1 vs. RTE	-2.03	.098
CD7 vs. RTE	-4.45	.007
CD3 vs. WRO	3.63	.015
CD2 vs. WRO	2.39	.063
CD1 vs. WRO	1.37	.229
CD7 vs. WRO	0.46	.666
RTE vs. WRO	3.75	.013

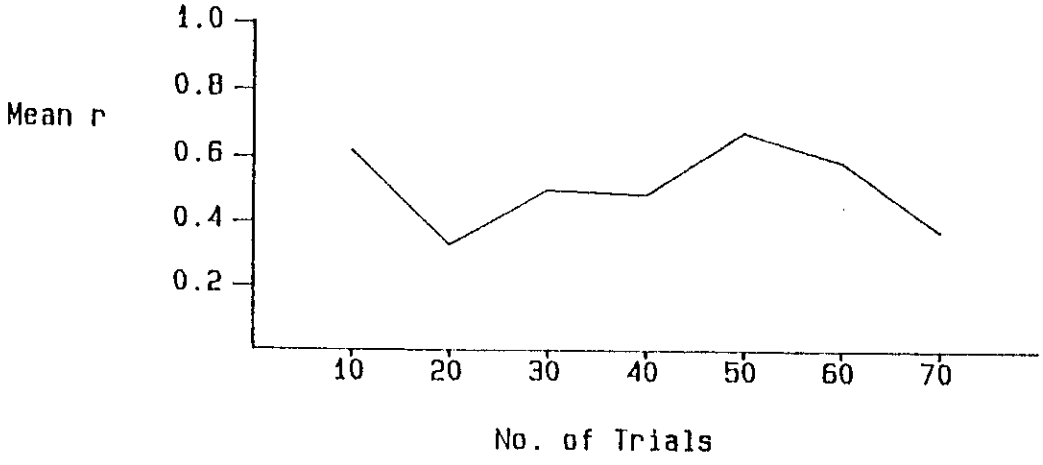
* Positive t indicates that the mean correlation for the left column was larger than for the right column; a negative t indicates that the right column was larger. All t-tests were performed on Fisher Z-transformed inter-channel correlation data.

Figure 1: INTER-CHANNEL CORRELATIONS



* See footnote Table 1.

Figure 1A: MEAN INTER-CHANNEL CORRELATION (r) PLOTTED AS A FUNCTION OF NUMBER OF TRIALS



II. Frequency Domain

The following terms are used throughout the remainder of this paper: delta (0 - 3.9 Hz), theta (4 - 7.9 Hz), alpha (8-12.9 Hz) and beta (13 Hz and above).

A. t-Tests of ERP Spectra

The current results are reported from trials with the value "Very Good," second highest rating on the six-point rating scale. This was done in order to achieve an adequate sample size of superior-performance data with a single performance value. FFTs from all eight epochs were combined to provide aggregate means and standard deviations for each frequency value.

Typical, average spectra for S indicated prominent beta activity; peaks were found, centered at various frequencies ranging from 20 Hz through 62.5 Hz. S had a somewhat unusual resting EEG, with larger than normal amounts of beta activity, in peaks 1 to 2 Hz wide, centered at frequencies including 25, 35, 48, and 52 Hz. S also had pronounced 7-9 Hz frequencies (alpha waves), and high-power frequency lines in the theta and delta wave region of the spectrum.

Two-tailed t-tests were applied to all pairs of frequency components (0.0 - 61.52 Hz); those significantly different at $p < .001$ are indicated in Figures 2 - 4. The significance levels were Bonfonerri corrected (Myers, 1972, p. 363) to control for Type I errors, inherent in multiple, post hoc comparisons. The correction has the effect of making these p values less significant; however, for $p < .001$ the correction is negligible, though theoretically important.

The results of these tests are summarized in Figures 2, 3 and 4 which display the significant frequencies for each electrode location in the form of a sign spectrum. These indicate which frequencies were significantly different ($p < .001$) and the direction of the change with a "+" or "-". Thus, in Figure 2-1, the "+" at 8.79 Hz for the Fpz-Oz derivation indicates that the mean for CD1 was greater than the mean for the Control Condition, and the t-test for this difference was significant at $p < .001$.

Figure 2-1: Compared with the Control Condition (CD7), when S entered CD1 there was increased alpha activity in all channels. In addition, beta activity decreased, particularly at Fz and Fpz-Oz. A narrow band of increased activity centered at 50.78 Hz appeared at C3 and Pz.

Figure 2-2: As S entered CD2 there were decreases in theta and delta in addition to more extensive decreases in beta activity. The 49.80 - 50.78 Hz activity continued to increase at Pz, as did alpha on all channels.

Figure 2-3: as S entered CD3 there was an increase in 3.91 Hz delta at C3 and C4; alpha continued to increase at Pz, C4 and Fpz-Oz. Beta activity was widely depressed at Fz, C3, and Fpz-Oz. Narrow energy bands appeared at 36.13 and 41.02 Hz at Pz and C4. The 49.80 - 51.76 Hz activity increased further at Pz. Delta activity at 0.98 and 1.95 Hz decreased further.

Examination of the results from CD3 vs. CD2, Figure 3-2, indicates more precisely the transition from CD2 to CD3, which is the key to S's "crossing the threshold." Notably, 3.91 Hz delta was significantly enhanced on all channels and beta was depressed on Fz, C3 and Fpz-Oz. Narrow bands of increased energy appeared, scattered among the channels except for Fpz-Oz, centered at 36.13, 41.02, 45.90, 50.78 and 60.55 Hz.

Comparisons of CD3 and CD1 are shown in Figure 3-3. The apparent overall similarity between these conditions was not expected and its meaning is not at present clear. The relatively few significant differences observed were primarily at C3 and were, without exception, negative in sign, indicating less power at these frequencies for CD3 than CD1, suggesting a deactivation of the left hemisphere associated with CD3. This trend began in Figure 3-1, continued in Figure 3-2 and on into Figure 3-3, suggesting a progressive process of deactivation.

The EEG spectra obtained during the Prediction Task were analyzed using the same procedures used for the State data. The results consisted of t-values computed between each spectral line from hit and miss trials. In these comparisons, significant differences were found only with derivations C4 and Fpz-Oz/Oz.

Referring to Figure 4, which depicts RTEs vs. WROs, RTE trials had significantly higher beta activity at 17 frequencies, again arranged as a series of narrow bands, spaced about 6 Hz apart from 11.72 - 22.46 Hz, and roughly 4 Hz apart from 30.27-57.62 Hz. This was evident only on C4. At Fpz-Oz/Oz, there was beta reduction for the RTE trials, particularly at 50.78 Hz, and above 57.62 Hz.

FB3 showed only one; the remaining 4 bands showed 3 significant values each.

The apparent inconsistencies between Figure 4 and Table 2 are due mainly to the different forms of analysis. The SDAs in Table 2 eliminate variables which are highly correlated. Also, the SDAs do not depend on significant mean differences; rather, the over-all pattern of classification is paramount.

Table 2: CLASSIFICATION ACCURACIES FROM CROSS-VALIDATION OF THE TWO PREDICTION-TASK SESSIONS WITH EACH OTHER

Frequency Bands (Hz)	Scalp Electrode Placements				
	Fz	C3	Pz	C4	Fpz-Oz/ Oz **
	CA% of the Model *				
1. 0.00 - 9.77	64.87	53.19	63.83	39.78	64.52
2. 10.74 - 20.51	66.97	51.06	63.83	63.44	64.52
3. 21.48 - 31.25	54.27	51.07	55.32	51.61	78.49
4. 32.23 - 41.99	67.02	58.51	63.83	50.54	65.59
5. 42.97 - 52.73	48.95	57.46	71.27	59.14	76.34
6. 53.71 - 62.50	37.20	59.57	39.36	60.22	69.89

* CA% = $\frac{\text{Session 1 + Session 2 Correct Classifications}}{\text{Total artifact-free trials}} \times 100$

Number of trials for session 1 was 24; for session 2, 70.

** Fpz-Oz derivation session 1 of Prediction task (24 artifact-free trials); Oz derivation session 2 (70 artifact-free trials).

Underlined entries: $p < .05$, one-tail normal approximation to the binomial, at CA = 59.01%.

Table 3 shows the CAs obtained when the model developed to discriminate the CD1 and CD3 State trials was applied to the data from the two sessions of the Prediction task. The most dramatic findings compared to those from the previous table were that C4 became predominant by showing 3 above-chance performance values (frequency bands 2 through 4), while Fpz-Oz/Oz, which previously had 6 significant values, showed none. Channels Fz, C3, and Pz showed one above-chance value. Over channels, FB2 preserved its predominance by yielding 2 above- chance values compared to 1 or 0 for the remainder of bands.

Table 3: CLASSIFICATION ACCURACIES FROM CROSS-VALIDATION OF CD1-CD3 MODEL ON PREDICTION-TASK SESSIONS

Frequency Bands (Hz)	Scalp Electrode Placements				
	Fz	C3	Pz	C4	Fpz-Oz/ Oz **
	CA% of the Model *				
1. 0.00 - 9.77	59.57	47.87	58.51	34.41	53.76
2. 10.74 - 20.51	56.38	52.13	60.64	65.59	51.61
3. 21.48 - 31.25	47.87	53.19	57.45	60.22	49.46
4. 32.23 - 41.99	54.25	55.32	57.44	59.14	36.56
5. 42.97 - 52.73	36.17	47.87	55.32	46.24	39.78
6. 53.71 - 62.50	53.19	67.00	50.00	52.69	40.86

*, **, __ See footnotes, Table 2.

Spectral values with significant incidences selected by the SDAs at each frequency band and electrode site for the State and Prediction Models are shown in Table 4. To take one spectral value as an example, 1.95 Hz was selected often enough within the 0.0 to 9.77 Hz band over the 8 sub-epochs prior to the termination response to attain statistical significance ($p < .05$, 2 - tailed) at leads C3 and Pz for the State Model, and at C3 for the Prediction Model. In order to facilitate certain later comparisons, pluses (+) are used to indicate those frequency-band-electrode cells in which the CA (See Table 3) attained statistical significance. For example, the State Model yielded a significant classification accuracy value within the 0.00 to 9.77 Hz band at Fz; thus, a + is placed in that FB-scalp electrode cell.

As shown in Table 4, there was some commonality of a small set of specific frequency values across channels and across the training samples from both tasks. However, there were also frequencies which were useful discriminators in only one or the other training samples.

Note that a portion of the Table 4 +s in the cross validation of both SDA models are in FB-electrode cells not having a spectral value with statistically significant incidence. In these cases, the SDA models selected broadband effects which rely on a large proportion of the FB spectrum, rather than a few, specific frequencies. Many more significant spectral incidences, falling within cells with significant hit rates, were found when the SDA models were based on Prediction Task data. However, the C4 lead

displayed a particularly strong tendency to utilize the entire frequency spectrum in the Prediction Model. This is borne out by the finding that 3 out of 5 of the "valueless cells" in the Prediction Model occurred at C4, whereas in the State Model this proportion was only 1 out of 3. The importance of C4 was also observed in Figure 4, showing paired spectral t-tests during the Prediction Task.

Table 5 summarizes the center frequency values and cases of significant CAs in each frequency band across electrode sites for State and Prediction Models. The term center frequency subsumes frequency values from Table 4 within the spread of two spectral value increments from each other ($\pm$ 0.98 Hz). This coalescence convention permits reduction of the total number of spectral values to a summary set of frequency values which stood out in the SD analyses.

Thus, the listed center frequency of 1.95 Hz in Table 5 subsumed the 2 instances of 1.95 Hz in FB1 of Table 4, as well as the 1 occurrence of 2.93 Hz found in the State Model. Similarly, 3 instances of the 1.95 center frequency were found in the Prediction Model: 1 case of 1.95 Hz, and 2 cases of 2.93 Hz. The table illustrates that the strongest commonality across models occurred at 1.95, 25.39, 40.04 Hz center spectral values, while a weaker commonality was seen at 16.60, 29.30, 57.62, and 60.55 Hz. Complete task specificity (no commonality) was seen at 8.79 Hz (Prediction Model), and at 44.92 Hz (State Model).

The tally of classification accuracies to the right in Table 5 reveals the number of times the cases in the center spectral value tally also belonged to a FB-electrode cell which showed a CA value. For example, in the Prediction Model in FB1 (See Table 4), there were 3 cases where the classification accuracy was significant, and the 1.95 Hz center frequency appeared in 2 of these cases. This fact is reflected in the entries 3 and 2 for the Prediction Model at the 1.95 Hz center spectral value.

Table 4: MODEL-SELECTED SPECTRAL VALUES (HZ) WITH SIGNIFICANT INCIDENCES* IN TWO STEP-WISE DISCRIMINANT ANALYSES

Frequency Band (Hz)	State Model: CD1-CD3					Prediction Model				
	Scalp Electrode Placements					Scalp Electrode Placements				
	Fz	C3	Pz	C4	Fpz-Oz	Fz	C3	Pz	C4	Fpz-Oz/Oz
1. 0.00-9.77	+	1.95	1.95	2.93		+	1.95	+		+
							5.86	2.93		2.93
						8.79		7.81		
										9.77
2. 10.74-20.51			+	+		11.72+	11.72	+	+	+
	16.60	16.60		14.65				16.60		
					18.56					
3. 21.48-31.25				+		22.46				+
				24.42			25.39		25.39	
						26.37		28.32		
					29.30					
										30.27
4. 32.33-41.99				+		32.23+		+		+
			40.04						35.16	
						41.02		40.04		40.04
5. 42.97-52.75		43.95						+	+	+
			44.92		44.92					
					46.88			49.81		
							51.76	50.78		
6. 53.71-62.50		+					+	55.67	+	+
	57.62				57.62					
		60.55	60.55				60.55			58.60

* Entries consist of spectral values which were selected repeatedly over multiple epochs, thereby attaining statistically significant incidence ($p < .05$, one-tail normal approximation to the binomial distribution).

\+ The plus (+) indicates that the denoted table cell (frequency band x electrode placement) was also statistically significant in Tables 2 and 3.

Table 5: TALLY OF CENTER FREQUENCY SPECTRAL VALUES AND ASSOCIATED CASES OF SIGNIFICANT CLASSIFICATION ACCURACY ACROSS ELECTRODES

Frequency Band (1)	Center Frequency Value (2) (Hz)	Center Frequency Value Tally (3)		Tally of Classification Accuracy Values (4)	
		State Model	Prediction Model	State Model	Prediction Model
1	1.95	3	3	0	2
1	8.79	0	3	0	3
2	16.60	2	1	0	1
3	25.39	1	3	1	0
3	29.30	1	2	0	1
4	40.04	1	3	0	3
5	44.92	3	0	0	0
5	50.78	0	3	0	1
6	57.62	2	1	0	1
6	60.55	2	1	1	1

(1) Frequency Band: See designations in Table 4.
(2) Center Frequency Value: Were abstracted from Table 4; these are the center frequencies with bandwidth + or - 1 spectral line (0.977 Hz) which were found across electrodes and tasks.
(3) Number of cases where the dominant spectral values were associated with a statistically significant total frequency band CA (the + designations, Table 4). A convention was adopted in which only values attaining a total tally of 3 or more occurrences over both models were counted.
(4) See Table 4 (the +s).

DISCUSSION

I. Time Domain

Correlation coefficients were regarded as an index of coordination of DC or slow wave activity between pairs of electrode locations. Mean inter-channel correlation is a global measure of the degree to which DC and slow wave activity are coordinated between midline frontal, midline parietal, and left and right central areas of the brain. It should be noted that this measure says little about the absolute DC levels or slow wave changes present in the waveforms, other than the degree to which these changes occur in common among the channels. However, an examination of the voltages upon which the correlations in Table 1 are based revealed increasing positivity in all channels of the RTE waveform, which reaches a peak near the mid-point of the epoch at 4000 msec, and a negative ramp begining two or three seconds prior to the end of the epoch and continuing until the button press response. No consistent waveshape was observed amoung channels in the WRO average. The final seconds of the WRO waveform appeared less negative than the RTE waveform at all sites except C3. Warren and Don (1986) also reported greater negativity in RTE than WRO averages, however, it was observed earlier in the epoch than the present study. Task differences between studies may account for this discrepancy. The CD3 waveform resembled the RTE waveform in the present study although the positive-going shift was more pronounced than in RTE. This waveshape is absent in some or all channels of the other State conditions.

Significantly higher inter-channel correlations for RTE than WRO trials, (see Figure 1) indicated that DC/slow wave activity was more highly coordinated between these sites when clairvoyant predictions were right than when they were wrong. Comparisons between the State and Prediction Task data were consistent with the hypothesis developed from the participant interviews of S: That CD3 and CD2 are more conducive to the psi-state than is CD1 or CD7. The degree of coordination of DC/slow wave between recorded locations was observed to be greater for CD3 than WRO trials. It also tended to be greater for CD2 than WRO, whereas CD1 and CD7 were not different from WRO on this measure. On the other hand, inter-channel coordination of DC/slow wave was not different for RTE and CD3 but was marginally greater for RTE than for CD2 or CD1, and significantly greater for RTE than CD7. These results are in accord with the above hypothesis.

Gevins et al. (1987) also observed greater inter-channel waveform similarity for accurate than inaccurate responses in a visuomotor performance task, although much shorter epochs were compared in that study. The present results suggest that inter-channel coordination of DC and slow waves occurring over epochs several seconds in length are also related to performance,

specifically in a clairvoyance task. An extensive literature indicates that physiological state and DC changes are highly correlated in certain states, such as slow-wave sleep, although in general the role of DC is less clear (Bechtereva, 1974). A clear relationship is found in CNV studies in which slow waves correlates with task involvement (Tecce, 1972); however, the size of the slow waves also varies with the specific task. Walter et al. (1964) believed that transient negative shifts were associated with cortical priming. Our data suggest that a widely distributed DC biasing of the cortex is an important part of the process under study. Focusing on the Mean column of Table 1, it is seen that the mean inter-channel correlations increase from CD1 through CD3, paralleling the deepening of the subjective state.

It is possible that the gross measure (mean inter-channel correlation) employed in the present analyses, necessitated by the small number of subjects, sessions, and the limited number of sites presently recorded, may have masked a greater DC coordination between some areas of the brain and a lesser coordination, or de-coupling, between others. It is anticipated that future experiments will address these questions by recording additional channels and by enabling statistical analyses of individual electrode pairings. Future studies employing new DC amplifiers will also be able to characterize absolute DC levels and wave shapes, which the present study could not address due to instrumentation and experimental design limitations.

II. Frequency Domain

A. t-Tests of Frequency Spectra

The t-test results identify frequencies which have a significantly different statistical distribution of spectral power values when different psi-conditions or psi-performance data are compared. To confirm the presence of these differences, a test was constructed in which individual trials were post-hoc classified as RTEs or WROs, based solely on frequency data chosen because they were identified in both the State Study and the Prediction Task: 11.72, 16.60, 30.27, 37.11, and 41.02 Hz. In the Prediction Task, RTE/WRO guesses were distinguished; while in the State Study CD3, CD2 and CD1 differences were indicated by this frequency set. Trials were classified by counting the number of epochs in which spectral power values were above a threshold value. It was possible to correctly classify 71% of the trials from a Prediction task session which contained 70 trials.

The data suggest a significant frequency domain EEG commonality among RTEs and CD2 and CD3. In all three cases a distinguishing factor is the appearance of beta activity located at regularly spaced peaks, particularly in the C4 channel. In addition, the CD2-CD3 transition is accompanied by an increase in

delta activity focused at 3.91 Hz on all channels.

The sharply defined frequency peaks observed are suggestive of a narrowband process, which typically implies an enduring, continuous cyclic wave in the EEG. Therefore, data from individual epochs were inspected, chosen from trials which exhibited large amounts of the noted spectral energy. It was observed that the spectral components varied considerably from epoch to epoch, which suggests, in contrast, a fleeting, transient wave event.

In order to reconcile these discrepancies, a feasibility model (Collura, 1987) was developed which replicated the observed spectral beta patterns on the basis of synchronized bursts of beta (35-40 Hz) activity. This model was based on the hypothesis that short bursts of this activity occur in particular epochs and not in others. This would give rise to the observed, sharp, distinguishing spectral lines, while being consistent with a fleeting, transient process. This model relates ripples in the EEG power spectral density to transient patterns of brain electrical activity (Saltzberg, 1976; Collura, 1987), which are presumed to be associated with the presence or absence of psi-related states.

Thus, the effects which were observed in the frequency domain have significant implications for the elucidation of transient, time-domain wave effects in the EEG which coincide with psi phenomena. It should be possible to confirm the presence of synchronized, psi-related EEG activity through the application of appropriate signal processing techniques. The current results provide a possible rationale for signal analysis, which might lead to a repeatable, prediction-oriented scheme in the time domain for EEG-based psi experimentation.

B. Stepwise Discriminant Analysis of Frequency Spectra

The finding that the model discriminating the phenomenological states (CD1 vs CD3) (Table 3) repeatedly selected spectral values differing from those picked by the discriminant model of the WRO/RTE data for the Prediction Task (Table 2) does not seem surprising, since the training data were from different tasks. However, that the phenomenological model also correctly classified a substantial number of trials (maximum of 67.00%) from the Prediction Task is very striking and possibly important. The fact that both models achieved moderate to high hit rates of the subjects' predictions is evidence for the proposition that both are tapping processes mutually related to the processing of the stimuli used in the Prediction Task.

The finding that the two models utilize different patterns of spectral values and perform differentially at different EEG leads suggests that the central nervous system may code the awareness of the contents of consciousness in a way different from how it codes

the processing of visuospatial information, though the involved frequencies tend to overlap (see below). The results in Table 2, where training and test set data were both from the Prediction Task, indicate that the model developed using data from the frontal-occipital lead (Fpz-Oz) performed very well at all six frequency bands; better, in fact, than the Fz lead. Thus, it follows that an apparently greater involvement of the Oz regions in accurate classification is consistent with what would also be expected if the subject were performing an ordinary perception task using visual stimulation.

The C4 lead was distinguished from the other leads in several respects for both tasks. First, as reported in Table 3, frequency activity at C4 for the State Model was significantly above chance in classifying the data from the Prediction Task for three of the six bands (FB2 through FB4) covering from 10.74 to 41.99 Hz. Second, as shown in Figure 4, average power at C4 was consistently and significantly greater for RTE than for WRO trials for 17 of 65 spectral values in approximately the same frequency range, and beyond. No such string of significant differences emerged at any of the other leads, although a small number of significant differences were observed at the Fpz-Oz lead.

For the Prediction Model a different set of spectral values was found related to above-chance classification of single trials in FB2, FB5 and FB6. Two of these bands (FB2 and FB5) overlap with the same frequency range delineated by the State Model. Thus, the neural tissue at and feeding into the C4 region seems to play a role in developing an awareness of altered mental states, as well as in the processing of stimulus information.

Frequency activity at the Fpz-Oz lead relevant to clairvoyant-like performance seems difficult to detect unless the discrimination model is developed using ERP data collected in a clairvoyant type of task. This statement is based on the finding of an absence of above-chance classification performance on the Prediction Task when data from a non-prediction (State) task were used as the basis (training) sample for selection of a set of discriminating frequencies at Fpz-Oz.

It is possible that some confounding occurred in applying the State Model, which was developed solely using Fpz-Oz as training data, to a test data set from the Prediction Task which was drawn from two sessions, one using data from an Fpz-Oz channel and another using data from a monopolar Oz channel. This confounding could conceivably push results in the direction of reduced hit rates due to application of a model developed on a bipolar (Fpz-Oz) to data recorded using a monopolar channel (Oz). However, comparison of the hit rates of Session 1 (the bipolar channel) with those of Session 2 (the monopolar channel) showed a difference of only 5.3%, a value too small to push the hit rate to statistical significance.

As can be seen for the State Model in Table 4, the percentage breakdown of the total number of spectral values attaining significant incidence was as follows: the Fz, C3, Pz, C4, and Fpz-Oz channels were responsible for 11, 22, 22, 17, and 28%, respectively. For example, in the State Model, the Fpz-Oz electrode showed 5 significant incidences out of a total of 18 for all electrodes, i.e., 28%. For the Prediction Model this breakdown was as follows: 22, 22, 30, 7, and 19%, respectively. In sum, in moving from the State to the Prediction Models the Fz and Pz channels showed an increase in proportion of significant spectral values utilized, while the C4 and Fpz-Oz/Oz channels showed a decrease. From a systems perspective, the former channels can be said to show an increase in redundancy, while the latter can be said to show a decrease.

All ten of the frequencies shown in Table 5 showed significant, above-chance incidences across eight epochs, and were selected initially because they contributed significantly and independently to the maximization of the difference between the group categories (i.e., RTE vs. WRO; CD1 vs. CD3). At the low frequency end of the spectrum, a single delta band (DC to 2.9 Hz) frequency (1.95 Hz) emerged as a significant discriminator of RTE and WRO trials. It is interesting that DC and the first spectral line, at 0.98 Hz, were not selected; given the large differences in the correlations found (Table 1; Figure 1) one would expect DC to be selected. There are several reasons for this: (1) the correlations were computed between channels while the SDAs were computed within each channel only; (2) the correlations were computed from averaged waveforms, thereby increasing the signal to noise ratio in the data, while the SDAs were computed from single-trial data; (3) the SDAs were done on FFTs of the data, the units of each spectral line being power, which does not distinguish between positive or negative-going trends in the data; it is precisely these trends in the time domain data which the correlations found; (4) SDAs pick the minimum set of variables required to optimize discrimination of the data; thus, correlated variables would not be among the final set of discriminators even though they may be physiologically important, such as a set of harmonics. A final point about the limitations of the present methodology concerns our use of AC amplifiers, which cannot record constant DC-level biases in the data channels; only changing DC levels would be recorded.

One center frequency listed in Table 5, 40.04 Hz, deserves comment because of evidence for its functional significance. In fact, evidence to be cited below, considers a wide band straddling the 40.04 Hz value from 36 to 44 Hz to constitute a functional unity. The other frequencies to either side of the 40.04 Hz value: 16.60, 25,39, 29.30 to the left, and 44.92, 50.78, 57.62 and 60.55 Hz to the right, will be lumped together and considered as beta activity (14 to 35 Hz, and 45 to 62.5 Hz). Some discussion is

later devoted to discussion of 8.79 Hz, because of its functional significance, and to 60.66 Hz, because of its appearance despite severe attenuation due to the use of a notch filter.

The 40.04 Hz center frequency was found in both models, but was associated with a significant total frequency band hit rate only in the Prediction Model (note the two +s in the Prediction Model, Table 4, at Pz and Fpz-Oz/Oz). This result was also found for all the other center frequencies, except for 25.39, 44.92 and 8.79 Hz. The latter two values were specific to the State and Prediction Models, respectively, and only the 8.79 Hz value was found associated with a significant CA. The 25.39 Hz value was found in both models, but was found associated with a significant hit rate only in the State model. This is of interest, since it means that somehow the occurrence of this frequency was inhibited in the prediction task.

The finding of a 40.04 center frequency is important because it has been found by Sheer's group to be involved in ordinary cognition and phenomenology (Sheer, 1970; Sheer, 1976; Bird et al., 1978; Spydell et al., 1979; Spydell and Sheer, 1982), as well as with significant classification of data from the Prediction Task using models developed from both presumptive psi conductive state data and psi performance data.

Other studies of the 40 Hz band from the parietal-occipital area have found it to be consistently associated with higher order cognitive processing. Sheer (1970, 1976) has advanced the hypothesis that 40 Hz activity indexes a state of "circumscribed cortical excitability," or "focused arousal." This activity is in contrast to, and somewhat independent from, the surrounding multifrequency beta activity found in widespread cortical areas, which occurs in a variety of arousing situations. In part, an increase in the 40 Hz band has been found to be time-locked to behavioral orienting responses, as well as to engagement in problem-solving activity in normal adults and children (See references cited above). Subjects trained to suppress 40 Hz were unable to continue the suppression when engaged in problem solving (Bird et al., 1978). It will remain for future research to demonstrate how the ERP activity of psi states differs from that seen during ordinary problem solving performance.

The presence of the 8.79 $\pm$ .98 Hz value in three cells of Table 4 with significant total frequency band hit rates for the Prediction Model suggests that the presence of alpha is a predominant discriminator only if the subject is engaged in processing information. Simply going into an altered state is not sufficient to make this value significantly predominant. It is well known that alpha occurs in visual and parietal brain areas during the absence or inhibition of visual attention to the environment (so-called rejection task) as compared to a task requiring attention to the environment (intake task) (Mulholland,

1972; Orne and Paskewitz, 1974; Ray and Cole, 1985). This evidence suggests that it was unlikely that the subject in the Prediction Task was strongly attending to external stimulation.

Cross-validation of the SDA models based on both the Prediction and State Task data scored above 50% in most cases, compared to a SDA model based on an odd/even division of the RTE trials from Session 2 of the Prediction Task. The later model scored below 50% in all but one FB-electrode cell and all were non-significant, as would be expected based on such an arbitrary division. Thus, it is unlikely that the significant cross-validations reported were due to chance.

Only one center frequency (60.55 Hz) was found in both models which was also a member of FB-electrode cells with above-chance total frequency band hit rates in both models. Even more specifically, this frequency also occurred at the same channel in both models (C3). This value, then, seems to be a particularly good candidate for a psi-state indicator. Note that this channel is contralateral to the responding hand, which suggests activity of neuronal populations related to pre-movement processes.

It is not likely that the 60.55 Hz value is somehow due to a simple contamination of the EEG data by the 60 Hz field from the power mains. Such contamination would not explain why this frequency contributed so prominently to discrimination of RTE from WRO trials. A sequence whereby the subject pressed two different buttons to demarcate his period of mental reflection was exactly the same for each trial, so a differential capacitive effect due to the pressing of different buttons cannot be posited as an explanation. The subject began the trial with one button press, and terminated it by pressing another button, which indicated his readiness to make a verbal report within seconds. Only EEG data between these two button presses were analyzed. Further, even if such a capacitive effect had been present, why would these be related to correct classification by the SDA model?

A seeming puzzle to the prominence of the 60.55 Hz and other high end frequencies is that these frequencies should have been largely obliterated by the 1/2 high amplitude frequency cut-off and especially by the 60 Hz notch filter. That the latter was largely effective is confirmed by the freedom of our EEG records from the taint of obvious 60 Hz noise. Our conclusion is that enough power from these frequencies still must have been present to serve as discriminators. In this regard it should be noted that SDA analysis, in general, tends to utilize data values to produce maximal hit rates (c.f. Gevins, 1987) even if the means of those values between conditions are not significantly different.

Further research is underway in an attempt to more precisely characterize the brain waves associated with psi phenomena. For example, it is planned to refine SDAs by removing marginal trials,

i.e., establishing a "garbage can" category of trials whose frequency values do not permit clear-cut classification into RTE or WRO categories, in an attempt to more sharply define exemplary RTEs and WROs. In like manner, future prediction task sessions will incorporate design changes which permit better localization in time of the psi event and which may thereby greatly reduce the amount of extraneous noise. Also, it is clear that more subjects need to be run to provide greater generalizability of the model. Additional recording channels need to be utilized, particularly over left and right hemisphere scalp locations, to explore further the possibility of differential hemispheric involvement suggested by the present findings. These improvements will also require enhanced computer graphics capability.

Finally, a word about security in the present study is in order. Over the course of our experimental work with S, in precognitive and clairvoyant tasks, he has scored well above chance in most cases. In some of the latter experiments, the targets were never in the same room or in physical contact with S, nor had he any opportunity to view them. This does not mean that more exhaustive, high-security methods could not have been employed to make the experimental control tighter--to further reduce the likelihood of cheating. Whether the reader wishes to regard S's scores as illustrative of the actions of an accomplished illusionist or mentalist, or as the valid scores of a clairvoyant, the usefulness of ERP methodology in the study these issues has been demonstrated. The data, which demonstrates the successful discrimination between RTE and WRO stands on its own. Further, we feel that the ERP methods are potentially robust enough to discriminate between tricks performed by accomplished mentalists--provided they agree to conform to our protocols--and veridical psi. We welcome the opportunity to study these individuals in the lab.

In summary, the present study demonstrated the usefulness of the ERP techniques for the study of psi phenomena. The spectral and time domain analyses (DC/slow wave) suggested ERP differences between psi-related phenomenological states and between right and wrong guesses in a clairvoyant task. SDAs demonstrated that RTE and WRO trials could be (discriminated) classified at above-chance levels, and further provided theoretical corroboration by classifying RTEs and WROs in the prediction task at above-chance levels, using SDA models developed on the phenomenological State data. A number of spectral frequencies, at various scalp locations, were seen to be involved. Even if S's Prediction Task scores had been only slightly above chance, or achieved by trickery, such voluntary control over the brain waves would constitute a remarkable performance. Whether or not accomplished illusionists can also exercise such mastery over their brain waves, thereby pushing the illusion to a deeper level, only further research can decide.

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State Specificity and Psi Testing

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Abstract

The purpose of this study was to investigate the hypothesis that certain altered states of consciousness can be related to successful clairvoyance, and that certain brain wave characteristics are common to both.

Event-related brain potentials (ERPs) were recorded from a single, high-scoring subject during two tasks. In the first task (State Study) the subject repeatedly cycled through three self-reported altered states of consciousness that he deemed to be involved in psi. In the second task (Prediction Study) he guessed Zener cards.

The data reported here were analyzed using ERP data from both tasks, which had been converted into frequency domain data using Fast Fourier Transforms (FFTs). Stepwise Discriminant Analysis (SDA) was used on 1/2 of the State Study data to develop a model to classify the remaining trials into the least (CD1) or most psi-conducive (CD3) altered states. The highest classification accuracy in the State Study SDA was for CD3 at the frontal cortex (67.21%, $p < .01$). Results of a second SDA model, developed on all of the State Study data and used to cross-validate incorrect and correct trials from the Prediction Study, suggest the existence of major differences in data from the two tasks.

T-tests were also performed on the spectral data of both tasks to test for the presence of significant differences among the altered states and among correct and incorrect clairvoyance trials. A complex pattern of significant differences was obtained; most striking was an increase in right hemisphere activity across the frequency spectrum for correct as compared to incorrect clairvoyant trials, including frequencies in the theta and "40 Hz" (36 - 44 Hz) bands, and a reduction in left hemisphere activity in CD3 as compared to CD1. The finding of greater power in the 40 Hz and theta bands, at the right hemisphere for correct compared to incorrect trials, has been replicated with another subject performing a similar clairvoyant task in our laboratory. "Forty Hz" has not previously been linked to psi; it is known to be associated with higher cognitive processes such as problem solving.

The results offer support for the hypothesis that psi is associated with certain altered states of consciousness having specific brain-physiological characteristics. The commonality between this state and clairvoyant performance was mainly characterized by (1) a reduction or reversal of left hemisphere dominance; and (2) a pattern of heightened cognitive activity at the occipital (visual) regions of the brain, as indicated by increased power in the beta range, particularly in the 40 Hz region.

INTRODUCTION

In our 1987 paper, "Event-Related Brain Potentials, Clairvoyance and a Phenomenological Model of Psi-Conducive States" (Don et al, 1987), event-related brain potentials (ERPs) were recorded from a psi-exceptional subject, Olof Jonsson (S). That paper reported the results of two studies: 1) a meditation study and 2) a clairvoyant prediction task. In the State Study, i.e., meditation study, S cycled repeatedly through three self-identified altered states which he deemed to be key points on the spectrum of altered states of consciousness related to psi. ERP data were recorded during these three "Conditions," as he called them, plus a mental-arithmetic control-condition. In the Prediction Study, ERPs were recorded while S engaged in a Zener-card, clairvoyant task.

In the analysis of these data, it was found that Stepwise Discriminant Analysis (SDA) (Dixon, 1971; 1985), a multivariate, pattern-recognition algorithm, was capable of classifying correct and incorrect clairvoyant predictions at above-chance levels. These analyses were carried out on the Fast Fourier transforms (FFTs) of the EEG data. Thus, there were significant differences in brain function, as measured in the EEG, between correct and incorrect clairvoyance.

What we wish to report here is an expansion and a re-analysis of another finding from the 1987 paper which was not completely developed there. It was found that an SDA model developed on the state-of-consciousness brain wave data, when applied to brain wave data recorded during the clairvoyant Prediction task, was able to classify correct and incorrect predictions at above-chance levels. This suggested the existence of a state phenomenon, common to both certain self-reported altered states of consciousness and correct clairvoyance. Thus, the data suggested that the present S had to be in specific psi-conducive states in order to make correct clairvoyant predictions. Although the notion of state-specificity has been advanced by Tart (1986) and others as one explanation of psi, this is the first report (as far as we have been able to ascertain) of electrophysiological data generalizing from a meditational task to a traditional psi task supporting that hypothesis.

The hypothesis that an altered state of consciousness, i.e., a psi-conducive state, is necessary for, or facilitates, the occurrence of psi, is frequently encountered in the parapsychological literature. A number of studies have sought to induce psi-conducive states in the testing session with procedures such as progressive relaxation (Braud & Braud, 1973), meditation (Osis & Bokert, 1971), biofeedback (Honorton et al., 1971), hypnosis (Rhine, 1946), sensory deprivation (Honorton & Harper, 1974), or by procedures designed to foster a right hemisphere mode of processing (Braud et al., 1975). Ullman et al. (1973) reported that psychic abilities, e.g., telepathy, may be enhanced during the dream state.

By engaging in extended participant observation with S, a phenomenological description emerged of a spectrum of states of consciousness which matched Jung's (1953) writings on the psychological aspects of alchemy. S described three points on this spectrum as Condition One (CD1), Condition Two (CD2) and Condition Three (CD3). Very briefly, Condition One was the most primitive altered state of consciousness; it was described as

being "black" and with little or no potential for psychic functioning. This appeared to be the nigredo of alchemy, the "black blacker than black" (Jung, 1953, p. 313). Condition Two seemed to correspond to the alchemic state called the "yellowing," (xanthosis) in which, according to S, some limited psychic work is possible. At the end of the spectrum lay Condition Three, the prime psychic state, the threshold of which being the "white light," which appeared to correspond to the leukosis. Again, this description of S's conscious experience was not native to S; at no time did S use the terminology of alchemy or Jung's writings, referring to these states merely as Condition One, Two and Three. In addition to this, the visualization processes employed by S were communicated in detail to E1 in an experiential, teaching mode.

The veridicality of psi ability showed by S has been raised in regard to experimental work done with S soon after he emigrated to the United States from Sweden. We have corresponded with a group of investigators who were involved in tests of S's ability at that time. Two of these researchers are still available who engaged in extended experimentation with S. Both their responses are on file in our offices; neither response lends support to the hypothesis of trickery as the basis of S's performance under formal, controlled conditions. We would appreciate written correspondence from any researcher who can substantiate any claims of fraud. So far our attempts to uncover such evidence have been fruitless. We will return to the issue of veridicality in light of the findings of this study, at the end of this paper. At the request of the Program Committee, a special Appendix appears, addressing the questions of security and possible fraud in this study.

METHODOLOGY

Procedure

Brain wave data were collected from two studies. The first (State Study) aimed at studying the brain waves during CD1, CD2, CD3 and "Serial Sevens", a mental-arithmetic control condition. The second set (Prediction Study) involved a forced-choice, five response, clairvoyant task during which brain wave data were also collected.

Subjects All measurements were made on one right-handed S, Olof Jonsson, with a reputation for achieving high scores on Zener card tasks.

Study One: Study of States of Consciousness (State Study) In this experimental/phenomenological section of the study S repeatedly cycled through the three self-identified altered states plus a control condition. S initiated the beginning of a new trial each time he entered a new Condition (in his subjective opinion), by pressing the trial initiate button. At the end of eight to 12 secs (self-paced) he pressed the termination button. He then announced how well he had achieved that particular state of consciousness by rating his subjective experience on a six-point scale, from poor to excellent.
Two hundred eighty-two artifact-free trials of State data were collected. The instrumentation and data processing procedures were identical with those described in Experiment Two, below,

except where noted. Additionally, the "Serial Sevens" control condition was run, which consisted of having S mentally and repeatedly subtracting 7 from a minuend randomly selected at the start of each Serial Sevens trial.

Study Two: Forced-Choice, Five-Response, Clairvoyant Prediction (Prediction Task)

Target Preparation A person (Target Preparer 1 - TP1) affiliated with the laboratory but not involved in the present experiments was given 100 Zener cards (20 of each symbol) and was instructed to affix two layers of blank, white, opaque adhesive labels over the symbol side of each card. Each label completely covered the card; thus, there was no preferential label orientation which might cue to certain card symbols. The labels completely prevented a viewer from recognizing the symbol, and the adhesive was such that the labels would not peel off without causing obvious tearing of the labels and permanent alteration of appearance of the outer surface of the cards. Two members of the laboratory staff attempted to discern the symbols under varying lighting conditions and angles of view, and were unable to do so. TP1 then affixed a small, adhesive tab on the back side of each card. All cards were placed in a paper bag, shaken vigorously, then were withdrawn one card at a time from the bag. As each card was withdrawn, it was numbered sequentially, starting with number one. Next, circles were scribed about the center of each card using a template, and the symbols removed by cutting about the circles. (These targets were originally prepared for another experiment which was not conducted.) Target preparation occurred one week prior to S returning to the laboratory site from his city of residence, a distance of some 2000 miles. TP1 performed the preparation in her private office with no other people present. TP1 then immediately gave the targets to E1 who placed them in an envelope which he put in the inside, breast pocket of his suit jacket. Some four hours later, immediately upon returning to his residence, E1 placed the targets in a locked filing cabinet located within a locked closet (high-security lock) until the experiment was performed the following week.

Random Number List Preparation Prior to the first experimental session, a list of 100 unique random numbers (1 - 100) was generated from a computer program embodying a pseudo random number generator; these numbers were used to select the targets during the experiment. The computer program was seeded using the random number function on a calculator.

Testing Protocol Similar to Warren and Don (1986), electrodes were applied to S in the subject chamber. Throughout the experiment, S remained in the subject chamber, a room adjacent to the computer room. He was seated in a high-back recliner chair and had a heavy, black, wooden, performance platform placed across his lap, which attached to the arms of the chair. This effectively prevented him from rising from his chair or turning around. One meter in front of S was a parabolic, flat-black, construction-board barrier. S's right hand rested at the base of the manipulandum, a numeric calculator key pad mounted on a base. The S's index and middle fingers rested on the two keys; movement of the hand was unnecessary.

During the session one of the experimenters (E1) was present in the subject chamber with S. E1 stood behind and to the left

of the subject chair in order to place the targets, as indicated by the random number list, on top of the S's left hand, which was immobile throughout the experiment. Between trials, E1 consulted the number list to determine the next stimulus presentation. The entire list was subject to E1's gaze. S was not permitted or able to look at the list; viewing the list would not have aided him in guessing the targets since it contained only sequence information. During the session, S was unable to see the list because of his seated, locked-in position, and because of the absence of reflective surfaces in the room. The cycle for each trial was as follows: (1) E1 initiated trial by placing a target indicated by random number list on top of S's left hand for 10 seconds (back of card toward S); (2) E1 removed target; (3) S then pressed the trial start button; (4) S waited from 10 to 12 seconds (self-paced) before pressing the trial termination button on the manipulandum; (5) S announced his guess; (6) S was allowed to blink and move his eyes. Note that no trial-to-trial or outcome feedback was ever given to S during the study. E1 waited more than two seconds before presenting the next target. One hundred trials were run; session length was about 45 minutes.

Prediction Task Supplemental Trials

Since only 72 Prediction Task trials (55 Correct and 17 Incorrect) were usable for EEG analysis after exclusion of artifact-containing trials, it was decided to pool these with an additional 24 artifact-free trials (21 Correct and 3 Incorrect) collected in a preliminary study two days prior to the main experiment. The target preparation procedure for this session was as follows. Ten randomly selected Zener cards were placed in opaque envelopes numbered 1-10, outside the presence of S. Trials were presented to S in the same fashion as in the main experiment, with the exception that envelopes instead of taped cards were placed on the back of S's hand. The 10 envelopes were presented 4 times each, the order remaining the same for each pass.

EEG Recording Sensormedics Corporation, sintered, non-polarizing, silver/silver-chloride electrodes were applied with adhesive electrode collars and surgical mastic. Beckman electrolyte gel was used to establish electrical contact between the surface of the scalp and other head surfaces and the electrodes, which were placed at Fz, C3, Pz, C4, and an occipital site midway between O1 and O2 (Oz) (International 10/20 system) referred to linked ears. In Study One, the State Study, and session 1 of the Prediction Study, instead of the Oz placement there was a bipolar Fpz-Oz derivation. EOGs, used to detect eye-movement artifacts, were recorded as the potential difference between electrodes placed above and to the right side of the right eye. A forehead ground was used. EMGs, used to detect the presence of muscle artifacts, were recorded. Three EMG electrode placements were used: (1) frontalis muscle, (2) digastric muscle (under the chin); these were linked and referred to (3) the right mastoid process. An AC amplifier integrated these signals; trials indicating EMG activity were excluded from further analysis. Electrode impedances were below 5 K ohms; Grass model 7P122 amplifiers with 8-second time constants were used in a Grass Model 78 polygraph. On the EMG channel only, the time constant was 0.2 secs. The one-half amplitude high frequency cut-off was set at 60 Hz on the EEG and EOG channels and 75 Hz on the EMG channel. A 60 Hz notch filter was used on the EEG

amplifiers. One-hundred microvolt pulses were recorded before the study in order to calibrate each channel.

Data were displayed real-time on the polygraph strip chart recorder and were simultaneously recorded on a Vetter FM tape recorder for off-line analysis. An eighth channel was used as an event channel to record the onset of each button press indicating start and termination of each trial.

Data Analysis

The EEG data plus the EOG, EMG and event channel were digitized at 125 samples/sec (8 msec per datum) on a Digital Equipment Corporation PDP-11/03 computer. A trial consisted of 8000 msec of data (1000 data points) per channel. In the State Study each trial consisted of 1000 data points per channel while S was in one of the identified Conditions. In the Prediction Study, each trial consisted of 1000 data points per channel while guessing the card symbol. In both studies eight 128-point FFTs were calculated for each data channel (average overlap of 3.5 data points per FFT), windowed with a split-cosine bell; the frequency range was 0 to 62.50 Hz with resolution of 0.977 Hz.

A total of 405 State trials and 140 card-guessing (Prediction) trials were collected, and extensively edited by computer and visual inspection. The editing excluded trials contaminated by artifacts due to eye blinks and movements, as well as instances of excessive electrode drift and EMG activity. Exclusion of EOG contaminated trials was necessary since large amplitude EOG signals masked EEG signals. EMG activity overlapped the higher EEG frequencies and thus necessitated exclusion of those trials. A total of 282 State and 96 Prediction trials were collected which were artifact free.

FFTs were analyzed by Stepwise Discriminant Analysis (SDA) (Dixon, 1971; 1985). The SDA developed a pair of linear equations, a so-called brain-event model, which utilized the brain data of a given channel to maximally discriminate CD1 and CD3 trials. The equation yielding the highest score determined the classification in an independent cross-validation sample. Thus, if the CD3 equation yielded a larger score than the CD1 equation the trial was classified as a CD3 trial. The accuracy of these equations in correctly classifying categories of trials will be referred to as the performance or classification accuracy (CA) of the SDA.

RESULTS AND DISCUSSION

Results reported here were derived from FFTs of the brain wave data. The following terms are used throughout the remainder of this paper: delta (δ, 1 - 3.9 Hz), theta (Θ, 4 - 7.9 Hz), alpha (α, 8 - 12.9 Hz) and beta (β, 13 Hz and above). Note that the spectral lines resulting from FFTs were computed at certain discrete frequencies; adjacent spectral values were $\pm$.98 Hz apart. Thus, the frequencies of the FFTs usually don't coincide exactly with the boundaries of delta, theta, alpha and beta.

A SDA was performed to discriminate brain waves associated with CD1 and CD3. A SDA model developed on the 1st sub-sample (about half) of the trials was cross-validated on the 2nd sub-sample; subsequently another SDA model, developed on the 2nd sub-sample was cross-validated on the 1st. Finally, a SDA model developed on the State Study data (all CD1 and CD3 trials combined) was used to classify incorrect and correct trials from

the Prediction Study. Table entries were obtained by applying the discriminant models to independent (trials not included in the training sample) sets of data, i.e., only cross-validations are reported. See Tables 1 and 2.

Two-tailed t-tests were also used to compare CD3 with CD1 and correct with incorrect trials. The t-test results are presented in Figures 1 and 2. While multiple statistical tests increase the probability of a type I error, two points should be noted: (1) The p-value times the number of tests gives the expected number of type I errors; thus, for $p < .05$ and 320 comparisons the expected number of type I errors is 16; for $p < .01$ this becomes 3. (2) When the number of significant differences greatly exceed that number expected by chance, the attribution of all these to type I error is clearly not justified. This is especially true where non-random patterns of significant differences occur, e.g., in clusters or "strings" of adjacent spectral lines. Also, because some spectral lines in the data are correlated the assumption of independence of data is not warranted. In such a case the probability of Type I error is less than if independence applied (Myers, p. 362, 1972). Therefore, the 16 and 3 expected Type I errors, above, are a conservative estimate.

It should be noted that the t-tests were computed on aggregated data (spectra of all eight epochs of each trial were averaged). In the present study SDAs were also run on aggregated data, whereas in our previous studies SDAs were required to analyze eight, 65-line spectra for each trial. Therefore, the present SDA results differ from those in our previous studies, and are a more conservative model. SDA analysis, in general, tends to produce maximal classification accuracy based on patterns in each case of data even if differences in population means are not significantly different (c.f. Gevins, 1987).

It should also be noted that the State Study conditions CD2 and "Serial Sevens" were not considered in detail in the present analyses. However, in an effort to substantiate S's contention that CD1 is closer to a normal, awake state, i.e., ordinary consciousness, than is CD3, a simple count was made of the number of significant t-test differences between each of the 3 altered states and the "Serial Sevens" condition, a state assumed to be representative of "ordinary consciousness." It was found that CD1 differed from "Serial Sevens" for 53 out of 320 (64 spectral lines at each of 5 channels) t-tests at the .001 level of significance. CD2 differed from "Serial Sevens" for 66 out of 320 tests and CD3 differed from "Serial Sevens" for 96 out of 320 tests at the .001 significance level. Chi-square = 675.58; df = 2; $p << .001$. These results support S's assertions that CD1, CD2 and CD3 represent, respectively, a continuum of altered states, each further removed from ordinary consciousness.

In Table 1, the classification of the State Study Conditions, indicated that three cells were significant at $p < .05$ while one was marginal at $p = .06$. Significant classifications were obtained at frontal, occipital and left hemisphere sites for Condition 3 data.

At the left hemisphere site (C3) only, both CD3 and CD1 data were significantly ($p < .05$) or near-significantly ($p < .06$) discriminated by the SDA. Comparing this to Figure 1, C3 yielded the greatest number of significant t-tests. There was more power in CD1 compared to CD3 at virtually every frequency of the

spectrum.

Turning to the frontal electrode (Fz), Table 1 indicated that Fz achieved the highest classification accuracy for the CD3 data. Figure 1 reveals that the second largest number of significant differences between CD3 and CD1 occured at Fz. These were found primarily in the mid to high beta range. Again, for most spectral lines there was more power in CD1 compared to CD3. In delta/theta there was more power in CD3 compared to CD1.

At the occipital electrode (Fpz-Oz/Oz), Table 1 reveals significant classification for CD3 trials. Figure 1 indicates the third-most number of significant differences there. This involved less power in CD3 than CD1 in high theta/alpha and again in very high beta. Increased power in CD3 was observed in the "40 Hz" band, i.e., 36 - 44 Hz; and in a spectral line near 50 Hz.

The SDA did not yield significant classifications at Pz or C4. Also, Figure 1 reveals few differences between CD3 and CD1 at these sites. At Pz, CD3 had more power in the "40 Hz" and higher beta frequencies and less power in the delta and alpha bands than did CD1. At C4, there was more delta/theta power and less alpha power for CD3 as compared to CD1.

Table 2 shows the classification accuracies obtained when the model developed to discriminate the CD1 and CD3 State trials was applied to the data from the two sessions of the Prediction task. Five cells of the table were significant at $p < .0002$ (SDA). The pattern of SDA classifications in Table 2 is highly unusual, the classification accuracies being well above or well below chance levels. This we attribute to major differences in the distribution of the data in the two tasks. In the Predication Task, in addition to producing a psi-conducive state, S also had to generate clairvoyant predictions, which required additional visualization operations and decision making processes.

At the left hemisphere site, C3, the SDA classified all of the Correct but none of the Incorrect trials into their respective categories. An examination of Figure 2 reveals increased power for Correct than for Incorrect trials in five spectral lines, including one each in the delta, alpha, beta I, "40 Hz," and high beta bands.

At the right hemisphere site, C4, the SDA classified Corrects better than Incorrect trials. Figure 2 reveals that there was a broad increase in power across the spectrum for Corrects relative to Incorrects, particularly in the beta frequencies, but also including several lines in the delta, theta and alpha regions.

At the occipital channel, Fpz-Oz/Oz, the SDA accurately classified all of the Corect and none of the Incorrect trials. For this channel Figure 2 indicates the second-largest number of significant differences, between Correct and Incorrect trials. There was more power for Corrects in all but three of the significant spectral lines.

At the frontal site (Fz), incorrect clairvoyant trials were classified above chance, whereas corrects were not. Turning to Figure 2, Fz exhibited more power for Correct compared to Incorrect trials at a number of frequencies throughout the beta range.

The SDA on data from the parietal site, Pz, classified Incorrect better than Corrects. Figure 2 shows that several spectral lines had more power for Incorrect than Correct

trials in alpha, and across the beta range.

Hemispheric Differences

One of the most striking findings in the present experiment was the differing patterns of EEG effects observed at the left and right cerebral hemispheres. The specialization of function of the two cerebral hemispheres is an active area of investigation in modern psychology. The evidence indicates that the left hemisphere supports language-dependent, logical and analytical thought processes, while the right hemisphere supports visuo-spatial, synthetic and wholistic modes of thought (Bogen, 1969). Several researchers have hypothesized an association between right hemisphere processes and psi (Braud, 1975; Broughton, 1975; 1976; Mitchell, 1981; Maher, 1986). Hemispheric differences in EEG power observed in the present experiments are consistent with this hypothesis.

In the State study, power was greater at the left hemisphere over most of the frequency spectrum in CD1 than in CD3. This effect was present in 11 out of 14 spectral lines in the delta, theta and alpha frequency bands, and for 36 out of 51 spectral lines in the beta range ($p < .05$ through .001). At the right hemisphere, power was greater for CD3 than CD1 in the delta and theta bands (both $p < .02$). Beta power recorded over the right hemisphere did not significantly differ between these states. This may be interpreted as a left hemisphere deactivation during CD3 relative to CD1, and offers support for our hypothesis that the CD1 state is closer to ordinary consciousness which typically involves left hemisphere modes of thought. In addition, comparing CD3 to the serial sevens control condition, we see a similar left hemisphere deactivation, and an even more striking right hemisphere activation, for CD3 relative to serial sevens (see Fig. 2-3, Don et al, 1987).

In the Prediction task, power was greater at the right hemisphere during correct compared to incorrect clairvoyance for 5 out of 14 spectral lines in the delta, theta and alpha bands and for 49 out of 51 spectral lines of the beta range ($p < .05$ through .001). At the left hemisphere electrode location, correct clairvoyance trials had more power than incorrect clairvoyance trials in only 5 spectral lines including one in each of the delta and alpha bands and three lines in the beta range ($p < .05$ through .01). The finding of a right hemisphere increase in EEG power across the frequency spectrum including the beta frequencies and the low EEG frequencies, i.e., theta, delta and alpha, during correct relative to incorrect trials suggests an activation of the right hemisphere associated with clairvoyance.

Theta

Theta power was observed to be greater at the right hemisphere for Correct vs. Incorrect trials and high delta/low theta activity was also greater for CD3 than CD1 at the right hemisphere but lower for CD3 than CD1 at the left. Theta activity has previously been associated with hypnogogic imagery, occurring at low levels of arousal (Green & Green, 1986), and has also been linked to psi (Healy, 1986).

Beta and "40 Hz"

An examination of the spectral features selected by the SDA model suggests that frequencies in the beta range, and the "40 Hz" region in particular, were central to discriminating CD1 and

CD3. Sheer's group (1970, 1976) defines the band 36 - 44 Hz as "40 Hz." T-tests (see Figure 1) revealed significant increases in power in or near the "40 Hz" region at the parietal and occipital cortex for CD3 compared to CD1. Power in this frequency band decreased at frontal and left hemisphere sites for CD3 relative to CD1. Figure 2 shows that power in the "40 Hz" region and other beta frequencies was greater for Correct than Incorrect trials at all recording sites, but particularly at the right hemisphere.

Other studies of the 40 Hz band from the tempero-parieto-occipital area have found it to be consistently associated with higher-order cognitive processing. Sheer (1970, 1976) has advanced the hypothesis that 40 Hz activity indexes a state of "circumscribed cortical excitability," or "focused arousal." This activity is in contrast to, and somewhat independent from, the surrounding multifrequency beta activity found in widespread cortical areas, which occurs in a variety of arousing situations. In part, an increase in the 40 Hz band has been found to be time-locked to behavioral orienting responses, as well as to engagement in problem-solving activity in normal adults and children (See references cited above). Subjects trained to suppress 40 Hz were unable to continue the suppression when engaged in problem solving (Bird et al., 1978). Forty Hertz has also been shown to be maximal over the hemisphere theoretically most involved in a particular task (Spydell et al., 1979; Spydell and Sheer, 1982).

The relationship of 40 Hz to psi phenomena has not been previously reported. However, in the course of the participant interaction with S, it became clear that S's methods, which are quite precise, were specifically directed at achieving and maintaining an ability to manipulate visual imagery. (In fact, these methods have now been well-described and the dialogue and interaction between S and E1 (NSD) documented in 200 pages of manuscript by NSD.) It is therefore consistent with the known functional significance of 40 Hz activity to suggest that it may, in the present tasks, be a reflection of the concentration and visualization techniques employed by S.

Summary of Major Findings

I. CD3 is an altered state further removed from the normal, waking state--as represented by the mental-arithmetic control condition--than is CD1, which is also an altered state.

II. Both CD3 and Correct clairvoyance involve a reduction or reversal of left hemisphere dominance as indicated by broad changes in the EEG power spectrum.

III. A pattern of heightened cognitive activity at the occipital (visual) region of the brain, as indicated by increased power in the beta range, particularly in the 40 Hz region and thought to reflect concentration or visualization techniques employed by S, was observed for CD3 relative to CD1 and for Correct relative to Incorrect trials.

IV. The finding of greater power in the theta and 40 Hz bands at the right hemisphere for correct compared to incorrect trials during the Prediction Task has been replicated in our laboratory with another subject performing a similar clairvoyant Task (See McDonough et al., this volume).

GENERAL DISCUSSION

The results offer support for the hypothesis that psi is associated with certain altered states of consciousness having specific brain-physiological characteristics. The commonality between this state and clairvoyant predictions was characterized mainly by (1) a reduction or reversal of left hemisphere dominance; and (2) a pattern of heightened cognitive activity at the posterior (visual) regions of the brain, particularly in the 40 Hz range.

While there was commonality in brain function between the two tasks studied here, there were also marked differences. During the clairvoyant task S used visualizations to access CD3; then additional visualizations were employed for the clairvoyant task per se. Thus, there were additional goals and more complex visualizations involved. The disjunctive cross-validations in Table 2 stem from major differences in the data from the two studies, as compared to those of Table 1.

This result conflicts with numerous metaphysical and popular accounts in which psi effects are supposed to occur by task disengagement; see, for example, Zen in the Art of Archery (Herrigel, 1953). Phenomenological elaboration, from the participant interview phase of the work, indicated that a process of goal formation followed by a shift into an appropriate state of consciousness was required for clairvoyant accuracy.

Returning to the issue of possible fraud, more skeptical readers of this report may feel that the ERP effects could have occurred even if S were cheating. In such a scenario, S would have had to have some technique for producing different psychological states in the State Task whose spectral ERP characteristics would parallel those he would produce later in the Prediction Task. Moreover, the ERP characteristics of each state would have to be statistically discriminable from the other: one to be evoked for CD1; the other for CD3.

In the Prediction Task S would have had to be able, by fraudulent means, to recognize the identity of all or most of the targets; call more correct than incorrect predictions; and generate a corresponding mental state prior to each type of prediction. S would have had to make sure that he produced the CD3 state before the correct predictions, and the CD1 state before the incorrect predictions.

A variant of this scenario would have had S learn to generate two mental reactions: During CD3 S would have to produce a state closely corresponding to the naturally occurring mental reaction which he would have after being correct (success state). During CD1 he would have to produce a second state corresponding to that he would have naturally produced after making an error (failure state).

However, the kinds of effects found in this study (low arousal states, and shift to right-hemisphere dominance) would contraindicate either scenario variant. In either case, the type of mental set required to produce this kind of simulation and/or replication of mental states on cue, particularly for the Prediction Task, would seem to require substantial cortical arousal. Moreover, arousal would be expected to be even greater for the left, as compared to the right hemisphere, due to the logical, propositional nature of the simulation involved in the

Prediction and/or State Tasks. Recall, however, that the arousal-related, beta range activity showed just the opposite result: greater power for the right than left hemisphere.

Thus, we believe the likelihood of a subject producing the observed pattern of ERP effects in both tasks is very remote. We believe the likelihood that the subject could have produced the Prediction Task results alone by fraud is somewhat less remote. Even with the most stringent safeguards, a critic will always be able to point out additional inadequacies. We feel the power of ERP methodology lies in its capability of providing additional information which can supplement and complement a given, reasonably stringent, behavioral psi design. This can be done by adding appropriate control conditions, and recording accompanying ERPs.

Here are two examples. We could add a control condition in which a subject was run using an obviously marked deck or set of envelopes. Another condition might be one in which S was asked to first memorize a sequence of stimuli, identical in nature to those he predicts using psi, and then carry out a run using this sequence of stimuli. In short, a catalogue of control conditions could be developed, and systematically explored using ERP recording during performance of the conditions. The ERP pattern associated with each type of control condition would serve as "signature" for that possible type of trick by a given subject.

Several recent studies have highlighted the sensitivity which ERP waveforms can show in response to exposures to specific meaningful stimuli (Rosenfeld et al., 1987; Farwell and Donchin, 1986). These studies showed that ERPs could detect subjects' previous involvement or acquaintance with a specific stimulus, or event related to that stimulus, even when they tried not to react to that stimulus. The results of these two studies suggest that in future investigations we should consider related paradigms. Also, we should resume our focus on the time, as well as the frequency domain, in attempting to elucidate the ERP differences between correct and incorrect psi predictions, as well as between psi predictions and various control conditions.

We think the pattern of results we have established suggests that ERPs can serve as indicators of both general and performance-relevant psi states. Further, we feel that the results we report may be more parsimoniously explained in terms of the operation of psi processes than in terms of subject fraud, although we are mindful of the theoretical obstacles of accepting the former explanation. Additionally, we also recognize the need to develop more task-relevant control conditions against which to compare the results of psi runs, and to more closely examine the usefulness of ERP changes in the time domain in discriminating correct and incorrect psi trials and in discriminating psi from non-psi control conditions.

In conclusion, we suggest that the observed results are consistent with the hypothesis of a psi-conducive state. We also realize that the results, in order to be completely convincing, need to be replicated with more subjects (this we have begun to do; See McDonough et al., this volume) and with ever more rigorously controlled experiments.

Table 1: CLASSIFICATION ACCURACIES FROM CROSS-VALIDATION OF THE TWO CD1-CD3 SAMPLES (SPLIT-HALF) WITH EACH OTHER

State Conditions	Scalp Electrode Placements: Fz	C3	Pz	C4	Fpz-Oz/ Oz **
	Classification accuracy (CA%) of the Model *				
Condition 1	55.74	60.66+	44.26	57.38	40.98
Condition 3	<u>67.21</u>	<u>62.30</u>	49.18	44.26	<u>63.94</u>

* CA%= $\frac{\text{Sample 1 + Sample 2 Correct Classifications}}{\text{Total artifact-free trials}} \times 100$

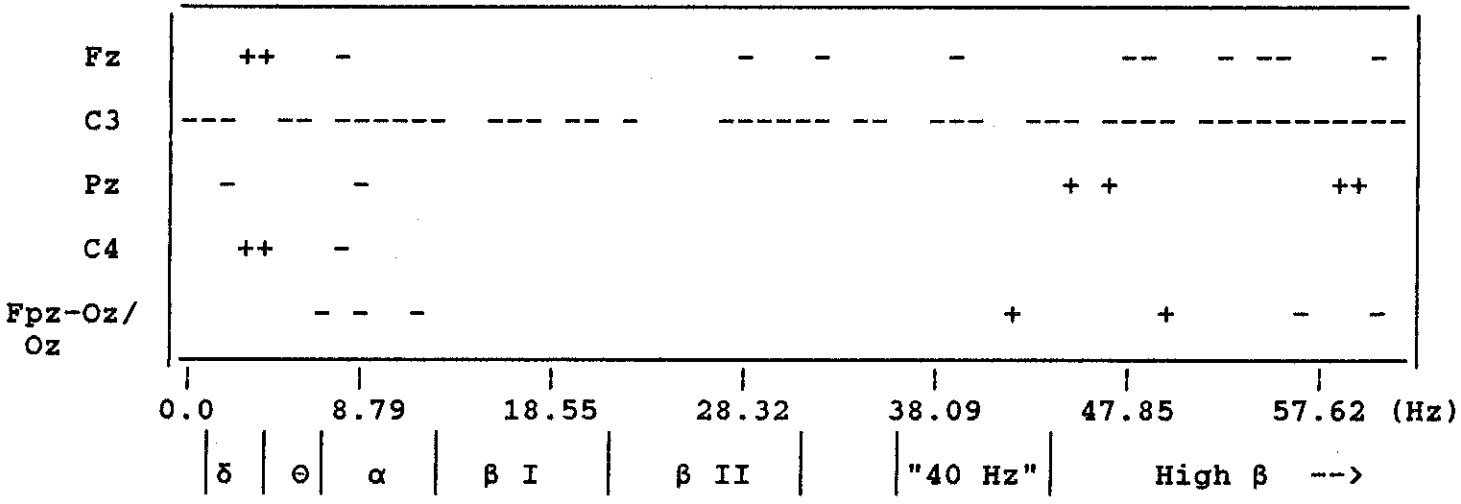
** Trials using the Fpz-Oz derivation (Oz referred to Fpz) and the Oz derivation (Oz referred to linked earlobes) were equally divided between samples.

<u>___</u> Underlined entries: $p < .05$, one-tail normal approximation to the binomial, at 62.30% hit rate; $p < .01$ at 67.21%

\+ entry $p = .06$

Number of trials in sample 1 was 62; 60 in sample 2; each containing an equal no. of CD1 and CD3.

Figure 1: STATE TASK: CD3 VS. CD1
SIGNIFICANT FREQUENCIES* FROM PAIRED T-TESTS ($p < 0.05$)



* The sign indicates the direction of significant differences: + indicates more power for CD3 than CD1; - indicates more power for CD1 than CD3.

Table 2: CLASSIFICATION ACCURACIES FROM CROSS-VALIDATION OF CD1-CD3 MODEL ON PREDICTION-TASK TRIALS

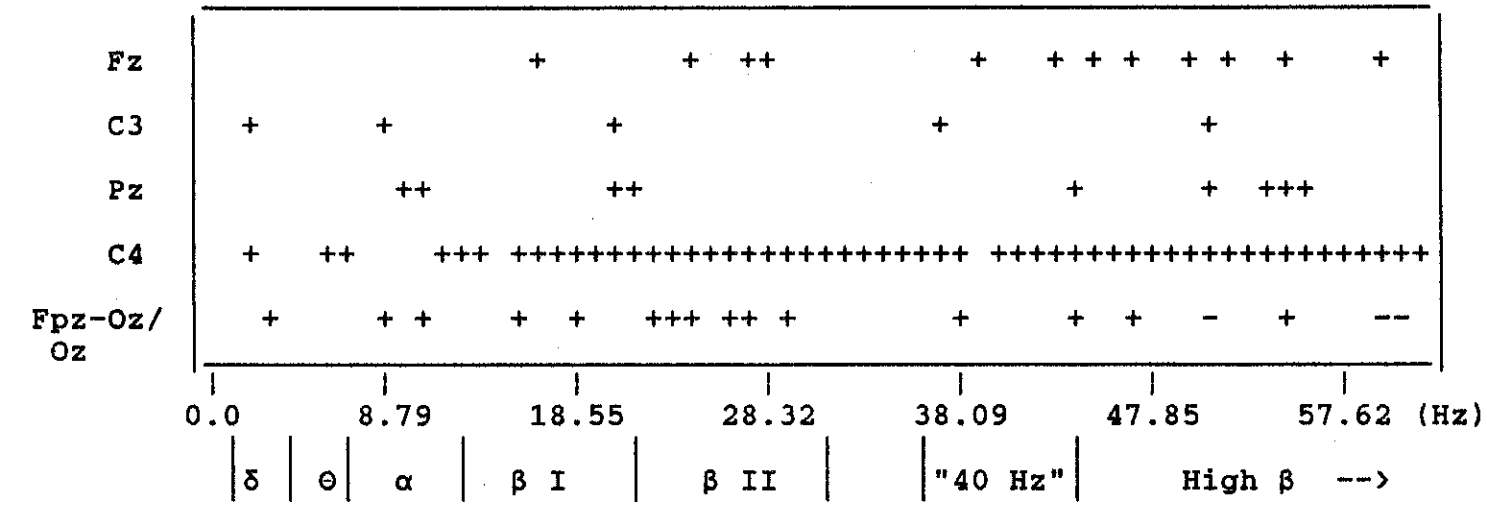
Performance	Scalp Electrode Placements: Fz	C3	Pz	C4	Fpz-Oz/Oz
	Classification Accuracy (CA%) of the Model *				
Incorrect	<u>90.00</u>	0.00	<u>90.00</u>	5.00	0.00
Correct	5.26	<u>100.00</u>	9.21	<u>93.42</u>	<u>100.00</u>

* CA% = $\frac{\text{Correct Classifications}}{\text{Total artifact-free trials}} \times 100$

__ Underlined entries: $p < .0002$, one-tail normal approximation to the binomial, at 90.00% hit rate.

Number of trials for Correct was 76; for Incorrect, 20.

Figure 2: PREDICTION TASK: CORRECT VS. INCORRECT ($p < .05$)



* The sign indicates the direction of significant differences: + indicates more power for Correct than Incorrect; - indicates more power for Incorrect than Correct.

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Appendix

The extremely high scores of the subject of this study invites intense scrutiny of the procedures used. The purpose of this appendix is to address the issue of stimulus security and possible fraud in this study. We do so, in part, by providing additional details about the conduct of the study, and discussion of the implications of our event-related potential (ERP) results. Additionally, we discuss Olof's possible use of tricks, and the role which operationalization of such tricks can play in future studies. In an attempt to provide an accurate update of our procedures we have carefully reviewed our notes and polygraph records. In retrospect, we feel we could have designed a tighter experiment. If Olof tricked us, however, we still haven't figured out how. Comments and criticism will be appreciated.

A. Additional Details Concerning the Study

A.1 Pre-experimental Setting: the Stimuli, Olof, and the Staff.

Before the cards were prepared by TP1, they were stored at the lab. The cards were stored in one of 5 rooms associated with the lab, in a locked steel box, in an out of sight, and out of the way location. The location of the stimuli was known to E2, and E3, but not E1, and no one else. The room in which the stimuli were stored was used exclusively by the authors of this paper. When not in use, the room was always locked when Olof was on the premises. This room is generally locked even when Olof is not present. It is also locked after working hours. Key access is also provided to the department secretary and to the evening cleaning crew (all of these personnel are totally blind to the nature of the study).

Moreover, to our knowledge, Olof has never visited the lab except in connection with a specific experiment he was to participate in. At the lab, he has always been escorted by one of the authors when present. Frequently he arrived for testing about 1/2 to 3/4 hour ahead of time. In this case we would seat him in an office, but never in the room in which the stimuli were stored. Olof never paced or explored about the building, but rather remained seated where we placed him. Occasionally he would read a newspaper, but mostly he would meditate.

The facility in which Olof stayed while in Chicago was never used for any of the formal experiments reported in this or in our previous papers. The lab in which Olof was tested was about 5 cross-town miles from where he stayed. The subject had no contact with the targets at any time, except during the experiment.

A.2 More on Stimulus Card Construction and Scoring.

As for the labels on the stimuli, during session 2 (100 trials), each of the labels completely covered the symbol side of the cards; two such labels were used per card to insure adequate stimulus shielding. These labels were "permanent," in that they would not easily peel off, revealing the symbols. Each card had to be ripped apart in order to expose the symbol. This was done jointly by E2 and E3. The checking of responses and the identity of the targets was done twice in order to check for errors. For

the card stimuli used in session 1 (supplemental trials), E1 and E2 opened the envelopes and scored the stimuli.

A.3 Activities by Participants Just Prior to the Study.

On the day of the study E1 removed the prepared stimuli from the filing cabinet, put them in his inside jacket pocket and drove (alone) with them to the lab. Olof was already at the lab in the subject chamber and was in the process of being wired up by E2, when E1 arrived. (E3 was not present for this or any of the state study sessions.) Olof told us he had taken a cab to the lab that day. E1 removed his jacket (leaving the stimuli inside) and placed it in a locked room several doors down from the subject room. During the session, Olof remained seated in the chair. E2 was in the room applying electrodes to Olof's head over a period of about 45 minutes, until the experiment began. As the application of the electrodes neared completion, E1 began to review and discuss the procedure for the study with Olof.

A.4 Probability of Subject Using Marked Stimulus.

(1) Due to the degree of security of the cards' storage, and the fact that we never allowed him to have physical contact with the stimuli, we feel that it was not possible for Olof to have physically marked the cards in an electromagnetic or visible fashion. We also never had any evidence that Olof employed a confederate.

(2) A logical possibility exists that subtle pre-existing visible or electromagnetic differences on the backs or edges of the cards which might have been used by the subject. But this would be possible only if these markings or signatures were common to the cards of most, or all, of such decks, i.e., due to the manufacturing process. We did not have the means to carry out an instrumented analysis of such possible differences, but we could not discern the presence of any stamp-through embossments.

The use of the circular symbol cutouts would, obviously, eliminate any pre-existing markings on the edges or anywhere near the edges of the card backs. The only remaining possibility for the card cutouts is that visible or electromagnetic cues had to exist on the center circular portion of the cards. Such preexisting cues, if present, would have also been available on the 10 standard stimulus cards, but the enclosure of each of these stimuli in envelopes would have precluded the use of visible cues.

(3) It is possible that the Zener cards differed slightly in mass. (We did not ascertain the degree to which Zener cards differed in mass.) If the cards with different symbols differed slightly but regularly in mass, it might be possible for a subject, with practice, to develop great facility in distinguishing the symbols based on this variable. Even if a subject could develop such facility by hefting cards resting on the back of his non-preferred hand, he probably would be rather unsuccessful when the cards were covered with gobs of adhesive tape.

A.5 More on the Testing Protocol.

It is not likely that Olof could have gained more information about the cards, once he was seated in the chair in the subject's chamber. E1 briefly touched each card to the back of the subject's left hand; the subject did not palpate the cards. Olof had an extremely limited opportunity to scrutinize each stimulus card for cues. As stated in the article, the subject was immobilized in a recliner chair with a performance platform across his lap. E1 was behind him, and only approached Olof's left side and hand in order to place a stimulus on his hand. His left hand was immobile on this platform, palm down, and the tape-covered card was placed on the top of his left hand, tape-side down. He was not able to move the left hand by any appreciable amount. Olof was continually reminded not to make bodily movements, which were not part of the experimental protocol. He was required to severely curtail eye blinking and eye-movement activity in order to provide acceptable ERP data.

A.6 Task Load on E1.

E1 presented the cards and recorded the responses. It was found from previous experiments using variations of the present design that the task demands on E1 were not excessive. The two lists of responses were compared after the experiment by E1 and E2.

A.7 ERP Findings Argue Against Fraud.

Now for the ERP findings, and this, finally, is the heart of the matter. The pattern of hemispheric laterality effects are consistent with legitimate psi performance, and are inconsistent with a fraud hypothesis (though we do not claim these results constitute definitive proof of psi). The differences in spectral power for the right vs. wrong predictions (See Fig. 2 in the main paper) demonstrate a clear pattern of right hemisphere activation for correct compared to incorrect responses. This finding is consistent with published studies in the parapsychological literature pointing to right hemisphere - as opposed to left hemisphere - involvement in psi (Maher, European J. of Parapsychology, 6, 1986; Maher & Schmeidler, J.A.S.P.R., 71, 1977; Braud, et al., Research in Parapsychology 1975, 1976; Broughton, Research in Parapsychology 1975, 1976; and others). If a subject were using some non-psi approach, such as observing a cue associated with a given target, from the literature on hemispheric specificity one would expect left hemisphere activation, not right (Bogen, Bulletin of the Los Angeles Neurological Society, 1969; Beaumont, in Dimond & Beaumont (Eds.), Hemisphere Function in the Human Brain, NY: Wiley, 1974; Bryden (Ed.) Laterality: Functional Asymmetry in the Intact Brain, London: Academic Press, 1982; Beaumont, (Ed.) Divided Visual Field Studies of Cerebral Organization, London: Academic Press, 1982; and many others). What would seem to be involved in a fraud scenario would be an analytic process: recognition or identification of the hypothetical cue, and symbolic/linguistic transformation from cue to response.

In addition, we found a marked, diminished activation at the left and frontal cortex during Condition 3, compared to the

Control condition (where the subject mentally subtracted 7 from an initial value). This is inconsistent with the notion that Condition 3 and observing a sensory cue (as in the prediction task) would generate similar brain states. Also, examination of the effects at C4 in the same data set revealed right hemisphere activation in CD3 compared to the serial sevens task, consistent with a right hemisphere effect. Thus, the neurophysiological evidence argues against this sort of fraud.

Similarly, the 40 Hz in the visual cortex is not indicative of a sensory or recognition effect. See the papers by Sheer, Spydell, etc. who make this very clear. Rather, as stated in the paper, 40 Hz is involved in higher-order cognition, such as problem solving. In this case it may well be indicative of the visualization process S used.

B. Deception and Non-Deception

There are reports and rumors that Olof has used trickery under both informal and formal, experimental conditions.

The question of whether Olof does use trickery under informal, uncontrolled conditions is important: Since, logically, if he can use tricks informally, then it is possible that he might use them under more controlled conditions. Equally important, however, is whether a significant number of Olof's demonstrations, informal or formal, are not easily explained by magicians' methods.

However, it is still not clear to us what Olof's ability to do good card tricks in an informal situation (when he may be permitted to palpate and otherwise inspect the cards, control runs through the cards, etc.) has to do with his ability to perform under the controlled situation where he is not allowed prior contact with the stimuli, and where, during the study, he is not allowed to casually palpate or inspect them, and where he is shown over 4 times the number of different cards he would work with when informally using a single Zener deck. Certainly, with tricks, as with all human abilities, task specificity is ubiquitous.

B.1 Importance of Operationalizing Deceptive Techniques.

The ideal experiment, which may not be entirely attainable in practical terms, would make it physically impossible for the S to cheat. In this case the question of subject trickery would be irrelevant.

On the road to this Nirvana state of the ultimate experiment or experiments, however, it is likely that much can be learned about what psi is not and what it is, through the study of the deceptive practices themselves. We feel that such a "subtractive approach" to the study of psi has a lot to offer. The power of the ERP approach, which we are only beginning to exploit, lies in its capability of providing distinctive signatures associated with whatever techniques a subject uses (See Discussion section).

Also, an understanding of exactly how Olof and other psi-exceptional subjects do their tricks (to the extent they do perform them) would be of great assistance in developing more adequate designs, and safeguards for future experiments. We must

inquire in detail as to the types of tricks Olof might be employing. This information will be of great help in designing a tighter study; one which would not permit him to employ such tricks, or which would inform us of those cases in which he did.