Technical Protocol for the MEG Investigation

Prepared by:

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Science Applications International Corporation

An Employee-Owned Company

Presented to:

The Scientific Oversight Committee

Submitted by:

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Menlo Park, California 94025

Science Applications International Corporation
Cognitive Sciences Laboratory
Memorandum

Date: January 6, 1992
To : Pete McDuff
From : Earling Degraff
Subject: LANL Experiments

Reference: ED92–006
Location: Los Alamos Inn
Location: Menlo Park

SG1J Ed asked me to call you, and since you are already on your way to LANL I thought I'd send you this lovely memo! Please ask the subjects to talk to [redacted] if they have any questions regarding the test results.

SG1J [redacted] does not want us to share any of the results with his people.

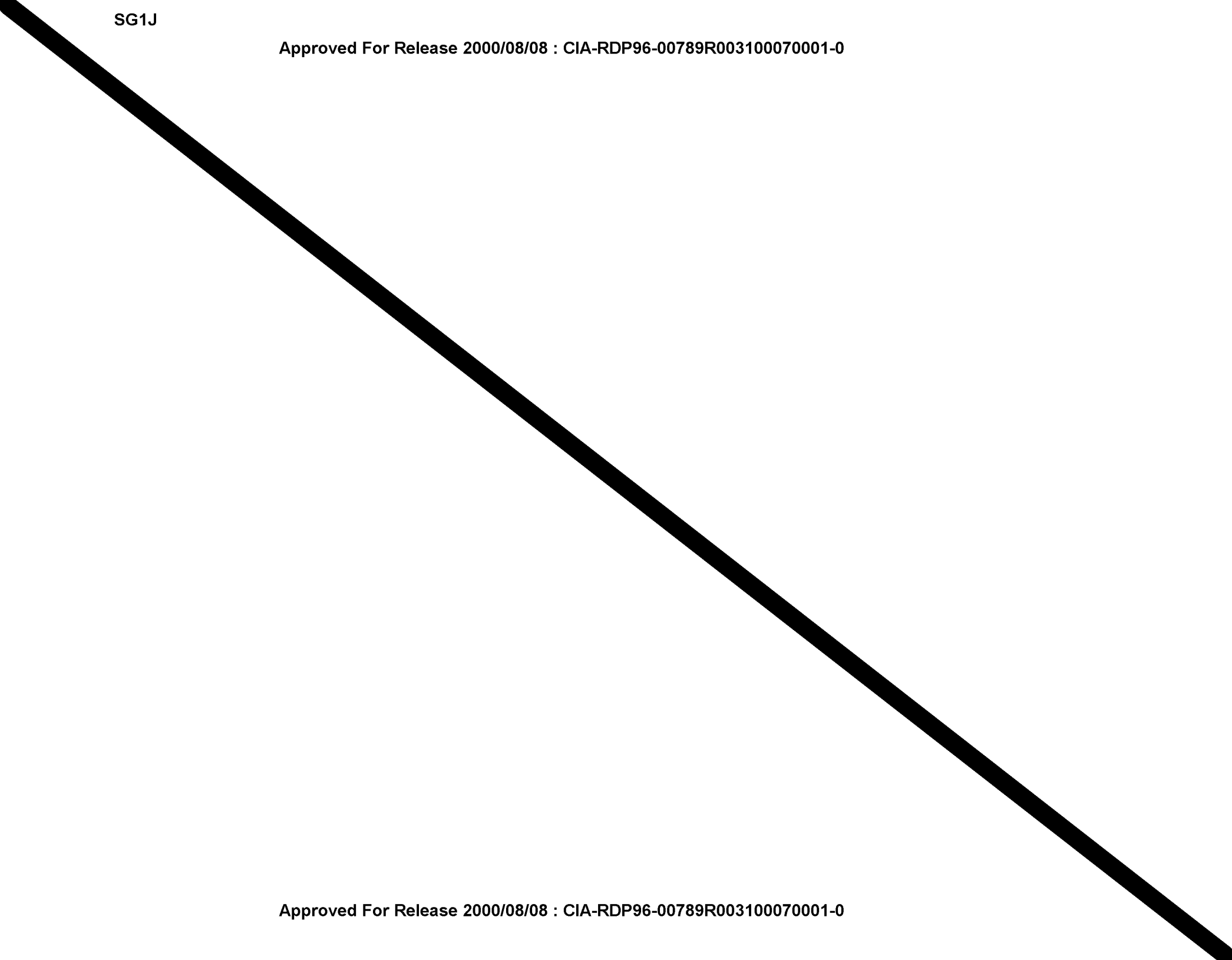
Enclosed are the *Block Data Sheets* for the trials at LANL. Also, enclosed is the *Experiment Schedule.*

Please feel free to contact me at (415) 325–8292 with any questions. Thank you!

enclosure

cc: Ed May
file

1010 El Camino Real, Suite 330. Menlo Park, California 94025. (415) 325–8292



Approved For Release 2000/08/08 : CIA-RDP96-00789R003100070001-0

BLOCK DATA SHEET

Receiver:_____ **Base ID:**_____

Block	Type	Date	Time	Stim 0	Run	Seed	Comments
___	e | c	__/__/__	__:__	rs | ps	01		
					02		
					03		
					04		
					05		
					06		
					07		
					08		
					09		
					10		
					11		
					12		

___	e | c	__/__/__	__:__	rs | ps	01		
					02		
					03		
					04		
					05		
					06		
					07		
					08		
					09		
					10		
					11		
					12		

Sender: _____
Experimenter 1: _____
Experimenter 2: _____
Others: _____

Base ID = iiddmm
Full ID = iiddmmtbb.rr

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12:28
1

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RESULTS OF MEG 1991–2

Receiver II (308): Type t

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	6	0.018±0.006	1.800	120	0.164	0.698±0.021	−0.263	117	−0.024
2	4	0.012±0.005	1.978	98	0.200	0.306±0.021	0.507	131	0.044
3	1	0.548±0.022	−1.305	122	−0.118	0.796±0.018	0.232	108	0.022
4	2	0.020±0.006	1.751	103	0.173	0.018±0.006	1.800	124	0.162
5	3	0.096±0.013	0.870	117	0.080	0.830±0.017	0.412	113	0.039

(///) = R.S.

control

Receiver II (308): Type s (Paired Sensors)

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	6	0.216±0.018	0.171	109	0.016	0.698±0.021	−0.263	125	−0.024
2	4	0.564±0.022	−1.136	110	−0.108	0.750±0.019	0.000	115	0.000
3	1	0.722±0.020	−0.141	116	−0.013	0.808±0.018	0.295	119	0.027
4	2	0.900±0.013	0.841	110	0.080	0.384±0.022	−0.732	123	−0.066
5	3	0.532±0.022	−1.522	119	−0.104	0.108±0.014	0.786	115	0.073

Receiver ww (708): Type s

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	7	0.232±0.019	0.090	129	0.008	0.024±0.007	1.665	103	0.164
2	6	0.958±0.009	1.379	124	0.124	0.968±0.008	1.522	112	0.114
3	6	0.884±0.014	0.732	105	0.071	0.252±0.019	−0.010	124	−0.001
4	7	0.512±0.022	−1.978	114	−0.185	0.002±0.002	2.653	119	0.243
5	6	0.998±0.002	2.653	115	0.247	0.198±0.018	0.263	108	0.025

Receiver ww (708): Type t (Paired Sensors)

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	7	0.822±0.017	0.369	128	0.033	0.886±0.015	0.631	108	0.060
2	6	0.342±0.021	−0.478	107	−0.046	0.018±0.006	1.800	129	0.158
3	6	0.248±0.019	0.010	115	0.009	0.782±0.019	0.161	118	0.015
4	7	0.258±0.020	−0.040	112	−0.004	0.534±0.022	−1.491	115	−0.139
5	6	0.350±0.021	−0.524	104	−0.051	0.134±0.015	0.619	125	0.055

Receiver gg (538): Type s

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	7	0.116±0.014	0.732	114	0.069	0.196±0.018	0.274	116	0.025
2	2	0.270±0.020	−0.100	115	−0.009	0.086±0.013	0.946	110	0.090
3	2	0.268±0.020	−0.090	113	−0.009	0.668±0.021	−0.423	118	−0.039
4	2	0.382±0.022	−0.719	110	−0.069	0.482±0.022	−1.800	121	−0.164

Receiver gg (538): Type t (Paired Sensors)

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	7	0.934±0.011	1.117	114	0.105	0.422±0.022	−1.011	119	−0.093
2	2	0.464±0.022	−1.461	113	−0.138	0.008±0.004	2.145	123	0.194
3	2	0.112±0.014	0.759	106	0.074	0.202±0.018	0.243	124	0.022
4	2	0.182±0.017	0.347	114	0.033	0.084±0.012	0.962	115	0.090

Receiver pp (329): Type s

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	2	0.218±0.019	0.161	111	0.015	0.330±0.021	−0.412	116	−0.038
2	2	0.388±0.022	−0.759	128	−0.067	0.188±0.018	0.316	109	0.030
3	2	0.322±0.021	−0.369	111	−0.035	0.288±0.020	−0.191	121	−0.017
4	6	0.350±0.021	−0.524	111	−0.050	0.732±0.020	−0.090	118	−0.008

Receiver pp (329): Type t (Paired Sensors)

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	2	0.138±0.015	0.594	103	0.059	0.588±0.022	−0.931	132	−0.081
2	2	0.154±0.016	0.501	111	0.048	0.048±0.010	1.305	124	0.117
3	2	0.060±0.011	1.175	106	0.114	0.008±0.004	2.145	131	0.187
4	6	0.430±0.022	−1.080	126	−0.096	0.028±0.007	1.590	103	0.157

Receiver ee (041): Type s

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	6	0.410±0.022	−0.915	101	−0.091	0.629±0.021	−0.295	123	−0.027
2	4	0.772±0.019	0.110	121	0.010	0.690±0.021	−0.305	114	−0.029
3	2	0.494±0.022	−2.258	121	−0.205	0.310±0.021	−0.337	110	−0.032
4	3	0.518±0.022	−1.800	89	−0.191	0.356±0.021	−0.559	116	−0.052

Receiver ee (041): Type t (Paired Sensors)

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	6	0.734±0.020	−0.081	105	−0.008	0.432±0.022	−1.099	126	−0.098
2	4	0.156±0.016	0.490	111	0.047	0.712±0.020	−0.191	96	−0.020
3	2	0.910±0.013	0.915	112	0.086	0.720±0.021	−0.157	116	−0.014
4	3	0.966±0.008	1.491	110	0.142	0.892±0.014	0.786	92	0.082

Receiver bb (172): Type s

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	1	0.996±0.03	2.409	128	0.213	0.270±0.020	−0.100	103	−0.010
2	3	0.748±0.019	−0.010	87	−0.001	0.888±0.014	0.759	96	0.077
3	7	0.206±0.018	0.222	122	0.020	0.730±0.020	−0.100	131	−0.009
4	1	0.726±0.020	−0.120	99	−0.012	0.036±0.008	1.461	110	0.139

Receiver bb (172): Type t (Paired Sensors)

Block	Sensor	Stimulus 0				Stimulus 1			
		P-value (1t)	Z (2t)	n	ES	P-value (1t)	Z (2t)	n	ES
1	1	0.356±0.021	−0.559	124	−0.050	0.202±0.018	0.243	105	0.024
2	3	0.998±0.002	2.653	122	0.240	0.274±0.020	−0.120	112	−0.011
3	7	0.930±0.011	1.080	122	0.098	0.244±0.019	0.030	130	0.003
4	1	0.638±0.022	−0.594	118	−0.055	0.814±0.017	0.326	113	0.031

Experimental Condition

Receiver	Remote Stimuli			Pseudo Stimuli			t(RS−PS)	df	p*
	$\bar{\varepsilon}$	N	p*	$\bar{\varepsilon}$	N	p*			
708	0.116±0.045	578	0.27	0.050±0.071	576	11.52	2.079	8	3.56
308	0.086±0.059	577	1.94	0.056±0.032	575	8.95	2.096	8	3.47
172	0.081±0.052	445	4.38	0.030±0.037	431	18.18	1.598	6	8.06
538	0.009±0.033	440	44.44	−0.037±0.049	468	74.88	1.557	6	8.53
329	0.0002±0.014	449	49.78	−0.043±0.011	476	82.74	4.853	6	0.14
041	−0.080±0.037	414	94.77	−0.069±0.047	481	93.49	−0.368	6	63.71
Total	0.059±0.028	2044	0.38	0.011±0.028	2095	30.73	2.424	2	6.39

* Times 10^{-2}

2903

$\bar{\epsilon} = .042$

Control Condition

Receiver	Remote Stimuli			Pseudo Stimuli			t(RS−PS)	df	p*
	$\bar{\varepsilon}$	N	p*	$\bar{\varepsilon}$	N	p*			
708	−0.010±0.037	573	59.46	0.034±0.036	588	20.48	−1.906	8	95.35
308	−0.020±0.031	573	63.39	−0.006±0.030	588	55.79	−1.348	8	89.28
172	−0.004±0.036	476	53.48	0.076±0.056	470	4.97	−2.875	6	98.56
538	0.053±0.061	462	12.81	0.020±0.055	466	33.07	0.804	6	22.61
329	0.112±0.020	436	0.968	0.014±0.067	500	37.65	2.925	6	1.32
041	0.026±0.039	427	29.33	0.023±0.045	441	31.62	0.101	6	46.16
Total	0.027±0.030	2044	10.72	0.015±0.009	2142	23.94	0.766	2	25.96

* Times 10^{-2}

Experiment vs Control

Receiver	Remote Stimuli			Pseudo Stimuli		
	t (E−C)	df	p*	t(E−C)	df	p*
708	4.836	8	0.06	0.449	8	33.25
308	3.556	8	0.37	3.161	8	0.67
172	2.688	6	1.81	−1.371	6	89.02
538	−1.269	6	87.42	−1.547	6	91.37
329	−9.159	6	99.99	−1.679	6	92.80
041	−3.944	6	98.50	−2.828	6	46.16
Total	1.560	2	12.59	−0.272	2	59.55

* Times 10^{-2}

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I OBJECTIVE

The objective of this FY 1991 effort is to replicate an earlier finding: The phase shift of the dominant alpha frequency of the central nervous system changes significantly as a result of a visual stimulus that is sensorially and physically isolated from the receiver.*

* Definitions of terms can be found in Section VII (i.e., Glossary) on page 19.

II BACKGROUND

In a series of experiments beginning in 1974, the central nervous system (CNS) of tested individuals was found to respond to remote isolated visual stimuli (i.e., flashing lights).[1,2,3*] The first experiment, conducted by Rebert and Turner,[1] involved randomly interleaved 10-second epochs (i.e., trials), during which either a flashing light (16 Hz) or no light was present in a sensorially and physically isolated room. When the light flashed, Rebert and Turner observed a significant decrease in the occipital α-power of isolated receivers. Two replications were conducted in collaboration with Galin and Ornstein at the Langley Porter Neuropsychiatric Institute in San Francisco. As reported by May et al., the results were inconclusive; the first replication confirmed the Rebert and Turner finding, a decrease of α-power concomitant with the flashing light, but the second replication attempt found an increase in α-power.[2]

Because of the advent of a more sensitive CNS monitoring device known as the magnetoencephalograph (MEG), which measures the magnetic field produced by activated neurons, and because of the additional 15 years of anomalous cognition experience, the basic experiment was repeated. May et al. found significant shifts in the phase of the dominant alpha frequency—similar to what might be expected in direct stimulation.[3]

A complete description of the MEG experiment is provided in the last paper in the Appendix; however, an overview is given here. Initially, the MEG was positioned over the occipital region at a location corresponding to the maximum magnetic field response to a direct light stimulus (i.e., 100-ms sinusoidal gratings in the lower left visual field of the receiver). For the experimental runs, the stimuli appeared on a TV monitor, which was isolated from the receiver† (i.e., the monitor was approximately 40 m from the shielded MEG room).

A block, ten runs of 2 minutes each, contained approximately 100 remote stimuli (RS) (i.e., the grating) and 100 pseudo stimuli (PS), which were blank screens. A second individual, who was known to the receiver, acted as a "sender" by observing the remote monitor throughout the 20-minute block.

Each stimulus was analyzed from −0.5 second before to +0.5 second after its onset. At the dominant α-frequency, which was determined from the average power spectrum, the relative phase shift during the same time interval was computed by standard fast fourier transform (FFT) techniques. The root-mean-square (RMS) phase, which was computed over the block separately for each stimulus type, was the dependent variable for the experiment.

Because brain-wave data are not statistically stationary, a Monte Carlo technique was used to determine if the observed RMS phases were exceptional. Since each 20-minute data set contained only 100 seconds of stimulus-derived data, this technique was considered as a *within-block* control.

* References may be found at the end of the document and are included in their entirety in the Appendix.

† Note that the stimulus is different from the earlier investigations. In stead of the 16-Hz, 10-second epochs, this experiment used sinusoidal gratings lasting about 100 ms.

The combined result for the RS for all 11 blocks in the experiment was 2σ from the Monte Carlo mean chance expectation ($z = 1.99, p \leq 0.024$) for a trial effect size of 0.060 ± 0.030. The combined result for the PS also deviated from chance ($z = 2.92, p \leq 0.002$) with an effect size of 0.092 ± 0.030.

The PS were initially conceived as an additional within-block control; however, there was no significant difference between the RS and PS, and thus the interpretation of these results is difficult. The results from *both* stimulus types exhibited significant deviations from the preponderance of the rest of the data (i.e., between stimuli time). The purpose of this replication attempt is to determine the cause of these putative effects.

III APPROACH

1. Experiment Replication

In this section, we provide details of a proposed replication of the earlier study.

1.1 Number of Trials

We *assume* that the observed trial effect sizes that were reported for the previous MEG study result from a putative AC effect. (See "Observation of Neuromagnetic Fields in Response to Remote Stimuli" in the Appendix.) Under the remote stimulus condition we found that at the trial level the effect size was 0.060 ± 0.030. The number of blocks was eleven and the approximate number of stimuli was 1,100.

To determine the number of trials necessary to provide a confident replication of the previous experiment, we conservatively use the observed effect size minus one standard deviation (i.e., 0.030). Using traditional statistical power analysis,* we find that the probability of observing a significant AC effect in only 1100 trials is 0.258. Conversely, if we require 95% confidence that a significant AC-effect could be observed, approximately 12,026 trials, or approximately 120 blocks of 100 trials each, are needed.

Twelve individuals have been identified as receivers for the formal replication. If we ask each of them to contribute ten blocks, then the probability of a significant replication over the total of 120 blocks is 0.95. In this case, a given receiver has a 60% chance of demonstrating an independently significant result if the AC hypothesis is true.

1.2 Receiver Selection

Twelve experienced receivers, who either participated in the earlier MEG study or are known to be "good" receivers from other investigations, will contribute ten blocks each in the formal replication study. Each receiver will contribute one block each day during a five-day visit to the MEG laboratory. The remaining five blocks will be obtained during a second five-day visit not less than two months after the first visit.

1.3 Sender Selection

Each receiver will chose a "sender."

1.4 Stimuli

The stimuli will be generated by a PC. Since each stimulus will occupy only a small, center portion of a standard TV image, most of the image is zero.

* A review of statistical power analysis is provided in Section V beginning on page 14.

1.4.1 Remote Stimuli

One high spatial-frequency and one low spatial-frequency sinusoidal grating are available as remote stimuli. The one that produces the maximum CNS response, when it is shown explicitly to the receiver, will be used as a remote stimulus throughout that receiver's ten blocks. Thus, the stimulus may be different for different receivers.

1.4.2 Pseudo Stimuli

All data bytes corresponding to the pseudo stimuli will be zero. Thus, the entire video image will correspond to a blank screen.

1.4.3 Stimulus Choice and Presentation

An HP workstation controls the collection of data and the presentation of the stimuli. Using a multiple congruent pseudo random algorithm (i.e., $R_{n+1} = a_0 \times R_n + b_0$, where a_0 and b_0 are constants, and $0 \leq R < 1.0$), the *nth + 1* stimulus is generated $3.0 + 4.5 \times R_{n+1}$ seconds after the *nth* stimulus. The algorithm is seeded from the system clock. The HP notifies the PC of the type and time for a stimulus. The PC waits until the next vertical retrace signal from its hardware-video-output board; switches pointers within the retrace cycle from the blank inter-stimulus (IS) frame buffer to one which contains either the RS or PS; and resets the buffer pointers after 100 ms (i.e., the stimulus duration = 100 ms). Figure 1 displays this sequence in graphical form.

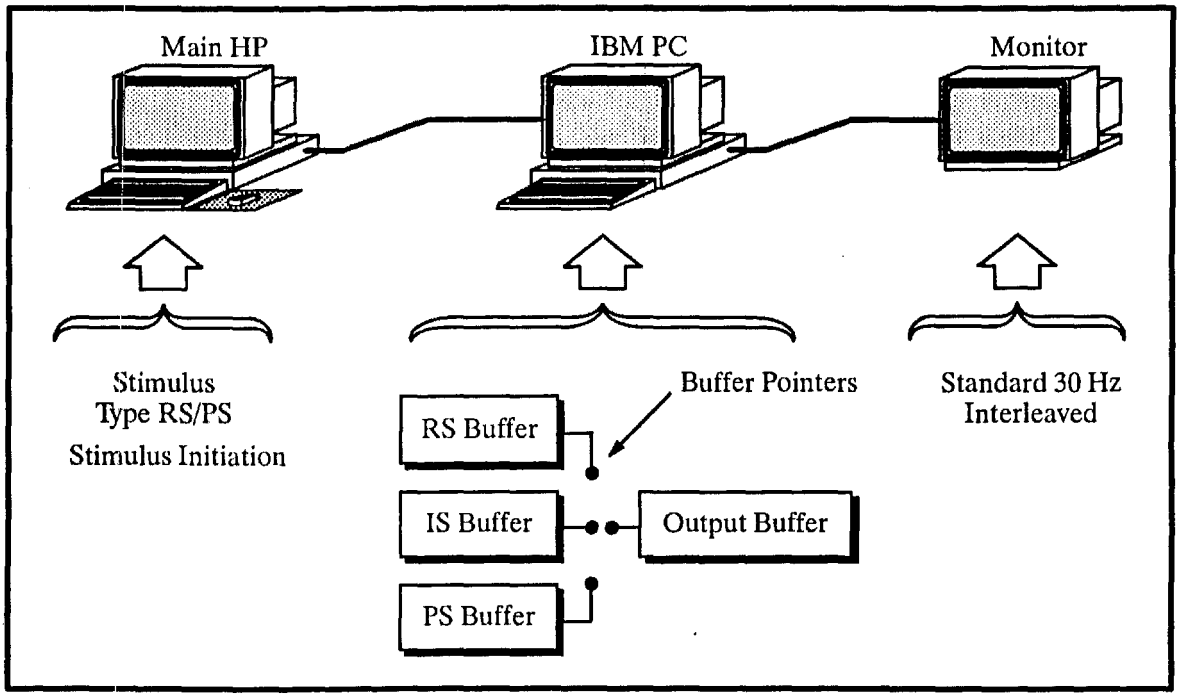

Figure 1. Sequence of Events for Stimuli Generation

1.5 Placement of the Seven-Sensor MEG Array

The placement of the seven-sensor MEG array is determined by an individual receiver's response to a direct light stimulus. While being stimulated by randomly interleaved low and high spatial-frequency gratings, sufficient stimuli (e.g., 30 to 50 of each type) will be collected to produce good signal-to-noise responses. The position of the sensor array, relative to head-based coordinates, will be recorded manu-

ally on a skull cap, so that the array can be repositioned accurately during subsequent blocks. The array position that will be used during the RS blocks is determined by the maximum response to these direct stimuli. See Section 1.6.1 for additional details.

1.6 Session Protocol

1.6.1 Location of MEG Array: Direct Stimuli

All receivers will be measured for their responses to direct stimuli. For this portion of the experiment, the stimuli will be generated three to four times faster (i.e., ≈ one per second) than in the AC portion of the experiment.

(1) The receiver is briefed about the experiment and is prepared for the session (i.e., removes metal, watches, etc.).*

(2) To a trained observer, the initial location of the array might be found within a few minutes; however, to arrange for the maximum response to be located as close as possible under the centermost sensor, the search might require an hour. Once found, sufficient data (i.e., 30 to 50 stimuli of each type) will be time-averaged so that the responses may be quantitatively defined, and the sensor positions are marked on the receiver's skull cap.

1.6.2 Anomalous Cognition: Remote and Pseudo Stimuli

We assume that the optimum sensor location has been determined.

(1) The receiver is briefed* about the experiment and is prepared for the session (i.e., removes metal, watches, etc.).

(2) Using the marking on the skull cap, the MEG array is repositioned as close as possible to the original calibration location.

(3) Its position is confirmed with direct stimuli, and adjustments are made, if they are necessary.

(4) The designated sender is positioned in front of the remote monitor, which is located approximately 40 m from the receiver.

(5) The video monitor, which presents the direct stimuli, is turned off.

(6) The receiver is instructed to relax with eyes closed. In addition, the receiver is given a few possible strategies that include focusing attention on the display that the sender is observing, the sender, or on both.*

(7) The receiver is notified, by intercom, that the run is about to begin.

(8) The run begins and seven channels of MEG data and one channel of stimulus data are collected for two minutes. The raw data are saved to disk, and the appropriate parameters for the next run are entered into the log book and the control program.

(9) After 5 runs, an experimenter quietly enters the MEG room, checks the MEG position, and readjusts it, if necessary.

(10) Five additional runs are collected.

(11) At the end of the block, the receiver enters the control room and is shown a computer display of the results of the last run. The experimenter points out interesting portions of the display, but cautions that the final results require careful analysis of all the runs, not just the last one.

* Please see the material that will be distributed to each receiver in Section VI beginning on page 16.

1.7 Controls

Two types of controls will be used in this experiment:

- Within-block: The data in the inter-stimulus times (IS) will be used as a within-block control.
- After-block: After each 20-minute experiment block, an additional block of ten runs will be taken under the same conditions as the experiment block, but without the receiver under the MEG. The sender, however, will be "sending" as before.

1.8 Data Recording

Along with the experimental parameters, eight channels of 200 per second data will be digitally recorded for later analysis (i.e., seven channels of MEG data and one channel of stimulus data).

1.9 Analysis

1.9.1 Overview

A block of data is ten, 2-minute runs. Each block contains approximately 100 RS and PS stimuli, respectively, from each of the seven sensors. The following will be computed for each stimulus type and for each sensor:

- Time averages for 0.5 second prestimulus to 0.5 second poststimulus.
- Separate average power spectra for the prestimulus and poststimulus time. The dominant alpha frequency will be determined from the centroid of the peak with the largest area above "background" for experiment blocks, and 10.0 Hz will be used for the after-block controls.
- Averages of the phase shift observed at the dominant α-frequency. The relative phase shift for a single stimulus is defined in Figure 2, and the RMS average is computed over the total number of stimuli in the block.

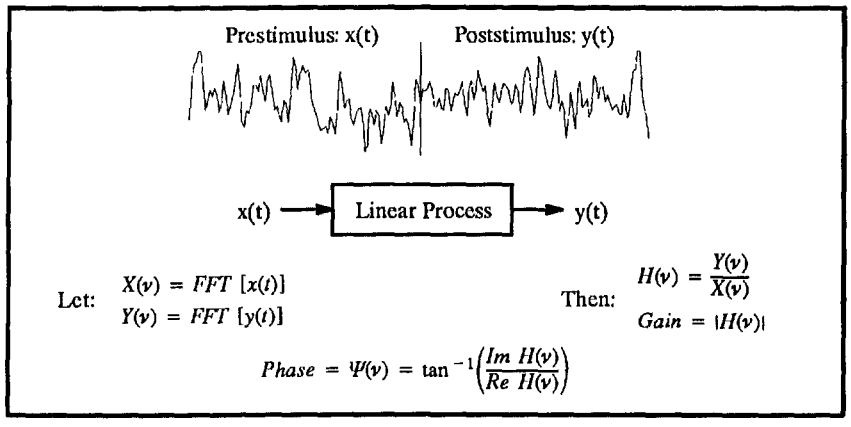

Figure 2. Phase Calculation for a Single Stimulus

The RMS average phase will be the dependent variable for the block. A Monte Carlo calculation will be used to determine the degree to which the observed phase shifts are deviant. If n is the number of stimuli in the data set, then each Monte Carlo pass will compute the RMS phase over n random entry points into the same 20-minute data set. The timing algorithm will be the same one used during the data collection; however, a new seed will start the process on each pass.

Statistics (e.g., p-values, z-scores) will be computed from the distribution of RMS phases derived from the Monte-Carlo-pass distribution.

Conceptually, a 2-tailed z-score will be calculated from a Monte Carlo distribution of phase shifts in the following way: Let μ_Ψ and σ_Ψ be the mean and standard deviation of the Monte Carlo phase shift distribution, and Ψ_0 be the observed RMS phase shift. Since the distribution of averages is approximately normal, compute:

$$z = \left| \frac{\Psi_0 - \mu_\Psi}{\sigma_\Psi} \right| \quad \text{and} \quad P = \frac{1}{\sqrt{2\pi}} \int_z^\infty e^{-0.5\varsigma^2} d\varsigma \, .$$

Since we have not specified a direction for a change in phase, the p-value for the block is given by:

$$p = 2 \times P,$$

and the two-tailed z-score, is computed from the inverse normal distribution for P. In the experiment, the empirical value of P will be used. That is, the number of Monte Carlo-derived RMS phases that are greater or equal to the observed RMS phase is divided by the total number of Monte Carlo passes. Therefore, the 1-σ error estimate in P will be computed from the binomial distribution for proportions. Or

$$1\text{-}\sigma \text{ error in P} = \sqrt{\frac{P\,(1-P)}{M}},$$

where M is the number of Monte Carlo Passes.

For this replication, the analysts will be "blind" to the identity of the receiver, the date, the condition (i.e., experimental or control run)*, and the stimulus type. We propose that SAIC and the MEG laboratory personnel carry out independent analyses of the same data.

1.9.2 Details

Let z_{ijst} be the 2-tailed z-score, which is derived from the Monte Carlo distributions for stimulus type i, block j, sensor s, and receiver t. Let the total number of trials (i.e., stimuli) for this condition be n_{ijt}, which is independent of sensor. Then the effect size in the experimental condition is defined as:

$$\varepsilon_{ijst}(e) = \frac{z_{ijst}(e)}{\sqrt{n_{ijt}(e)}} \pm \sigma_{ijt}(e), \quad \text{where} \quad \sigma_{ijt}(e) = \frac{1}{\sqrt{n_{ijt}(e)}}.$$

There is a set of effect sizes, which is derived from the experimental condition, $\varepsilon_{ijst}\,(e)$, and a set, which is derived from the after-block control condition, $\varepsilon_{ijst}\,(c)$. As was discussed in Section 1.9.1 above, the sensor (i.e., the value of s), that is used in the analysis of the experimental condition is the one that measures the largest prestimulus average α-power.

The sensor for the after-block control condition will be the same one chosen for the experimental condition. Thus,

$$\varepsilon_{ijst}(c) = \frac{z_{ijst}(c)}{\sqrt{n_{ijt}(c)}} \pm \sigma_{ijt}(c), \quad \text{where} \quad \sigma_{ijt}(c) = \frac{1}{\sqrt{n_{ijt}(c)}}.$$

These effect sizes will be used for all the hypothesis testing.

* By looking at the average power spectra, it may be possible to recognize a control condition from an experimental one.

1.9.3 Hypotheses Testing

Let N_t be the total number of blocks for receiver t. The overall effect size for the experimental condition is a weighted average over blocks. Or

$$\bar{\varepsilon}_{it}(e) = \sum_{j=1}^{N_t(e)} w_{ijt}(e)\ \varepsilon_{ijst}(e) \pm sd_{it}(e) \text{ where } w_{ijt}(e) = \frac{n_{ijt}(e)}{\mathcal{N}_{it}(e)} \text{ and} \tag{1}$$

$$sd_{it}(e) = \sqrt{\frac{\sum_{j=1}^{N_t(e)} w_{ijt}(e)\ \left(\bar{\varepsilon}_{it}(e) - \varepsilon_{ijst}(e)\right)^2}{N_t(e) - 1}}.$$

The overall effect size for the after-block control condition is similar:

$$\bar{\varepsilon}_{it}(c) = \sum_{j=1}^{N_t(c)} w_{ijt}(c)\ \varepsilon_{ijst}(c) \pm sd_{it}(c) \text{ where } w_{ijt}(c) = \frac{n_{ijt}(c)}{\mathcal{N}_{it}(c)} \text{ and} \tag{2}$$

$$sd_{it}(c) = \sqrt{\frac{\sum_{j=1}^{N_t(c)} w_{ijt}(c)\ \left(\bar{\varepsilon}_{it}(c) - \varepsilon_{ijst}(c)\right)^2}{N_t(c) - 1}}.$$

The $\mathcal{N}_{it}$ in Equations 1 and 2 are the the total number of i stimuli over N_t blocks for the experimental and control conditions, respectively.

Table 1 shows the hypotheses that will be tested for each receiver. The experiment and after-block control conditions are indicated by e and c, respectively, and each hypothesis is tested against its chance expectation.

Table 1

Hypothesis Testing for Each Receiver

Hypothesis	Test	Test Quantity
1. RS(e) have no effect.	z-score	$\sqrt{n_{0t}(e)}\ \varepsilon_{ot}(e)$
2. PS(e) have no effect.	z-score	$\sqrt{n_{1t}(e)}\ \varepsilon_{1t}(e)$
3. RS(c) have no effect.	z-score	$\sqrt{n_{0t}(c)}\ \varepsilon_{ot}(c)$
4. PS(c) have no effect.	z-score	$\sqrt{n_{1t}(c)}\ \varepsilon_{1t}(c)$
5. No RS(e)/RS(c) difference.	t	$\frac{\bar{\varepsilon}_{0t}(e) - \bar{\varepsilon}_{0t}(c)}{\sigma_p(0)\sqrt{\frac{1}{N_t(e)} + \frac{1}{N_t(c)}}}$

Table 1 (continued)

Hypothesis Testing for Each Receiver

Hypothesis	Test	Test Quantity
6. No PS(e)/PS(c) difference.	t	$\frac{\bar{\varepsilon}_{1,t}(e) - \bar{\varepsilon}_{1,t}(c)}{\sigma_p(1)\sqrt{\frac{1}{N_t(e)} + \frac{1}{N_t(c)}}}$
7. No RS(e)/PS(e) difference.	t	$\frac{\bar{\varepsilon}_{o,t}(e) - \bar{\varepsilon}_{1,t}(e)}{\sigma_p(0)\sqrt{\frac{1}{N_t(e)} + \frac{1}{N_t(e)}}}$

In Table 1, σ_p is the square root of the pooled variances and is given by:

$$\sigma_p(i) = \left[\frac{(N_t(e) - 1)\, sd_{i,t}^2(e) + (N_t(c) - 1)\, sd_{i,t}^2(c)}{N_t(e) + N_t(c) - 2}\right]^{\frac{1}{2}}.$$

2. MEG System and Environment Calibration

2.1 Empirical

For empirical calibrations, the MEG system is examined under the same conditions for the experiment, except there will be no CNS under the sensors.

2.1.1 Number of Blocks

In the experimental case, the number of blocks required was based upon an assumption that the previously observed effects were due to AC. For the empirical calibrations, we assume that those effects are primarily due to some unknown artifact. To achieve a 95% confidence level of seeing a significant artifact, the total number of blocks required is 120.

2.1.2 Types of Calibration

We propose that four types of calibration be done. Each calibration will involve 120 blocks of approximately 100 remote and 100 pseudo stimuli per block in each of the following conditions:

(1) No sender and no receiver.
(2) One sender and no receiver. The after-block control runs can be used for this calibration.
(3) One sender and a tissue equivalent receiver (e.g., saline solution).
(4) One sender and a selected, non-brain receiver body part (e.g., leg).

The total time required for this activity is 80, 3-hour days.

2.1.3 Analysis

The analysis of these data will be identical to that done for data collected under experimental conditions (see Section 1.9 for details).

2.2 Physical Calibration

Using the appropriate hardware, the electromagnetic radiation due to computer or other potential electromagnetic-interference sources will be measured inside the shielded MEG room. The time required for this activity is approximately 5 days.

IV DISCUSSIONS AND CONCLUSIONS

This replication attempt consists of 120 blocks of experiment data and 120 blocks of after-block control data; thus 240, two-tailed effect sizes are available for global analysis (i.e., Equations 1 and 2 on page 9). As shown in Table 2 (i.e., a portion of Table 1), we propose various z-score and t-tests. Since a number of results are possible from this experiment, we describe each and suggest conclusions and further actions to be taken. In Table 2, the experiment and after-block control conditions are indicated by *e* and *c*, respectively, and each hypothesis is tested against its chance expectation.

Table 2

Overview of Hypothesis Testing

Hypothesis	Test
1. RS(e) have no effect.	z-score
2. PS(e) have no effect.	z-score
3. RS(c) have no effect.	z-score
4. PS(c) have no effect.	z-score
5. No RS(e)/RS(c) difference.	t
6. No PS(e)/PS(c) difference.	t
7. No PS(e)/PS(e) difference.	t

1. Null Result

At the 95% confidence level, no statistically significant deviations are observed for the remote stimuli or the pseudo stimuli summed across all 12 receivers—that is, the combined z-score indicated by Hypotheses 1 and 2 in Table 2 are not significant. If a X^2 test for homogeneity of effect size demonstrates that the data are homogeneous (i.e., $p(X^2) > 0.05$), then we conclude that the experiment failed to replicate the original MEG study. We would recommend that no further MEG experimentation of this type be done.

If, however, the effect size across receivers is *not* homogeneous (i.e., $p(X^2) \leq 0.05$), then the data for each receiver will be examined individually. Depending upon available resources and the advice of the SOC, the receivers who may have demonstrated individually significant results might be asked to contribute additional data.

In behavioral sciences, it is tempting to sum across subjects; however, if exceptional behavior is being studied, summing can be problematical. For example, averaging the high-jumping results of a world

record setter into the data from the general population would not reveal an exceptional ability. Within-subject performance (i.e., homogeneity) is what is important in studying exceptions.

2. Significant Deviations

Significant deviations could be observed in both the experiment blocks and after-block controls or in the experiment blocks alone. Each case is discussed below.

2.1 After-block Controls

Suppose that, while significant deviations were observed in the experimental conditions, they were also observed in the after-block control data (i.e., no significant difference between experiment and after-block controls by the t-test for hypotheses 5 and 6 in Table 2).

If no significant artifacts were observed in the calibration blocks, but small amounts of electromagnetic interference (EMI) were observed in the physical calibration, then it may be that human brains respond to weak electromagnetic stimuli directly. This may be of interest to the general neuroscience community, but for this program, we would recommend no further MEG activity of this type. If no EMI were observed, then a more subtle artifact likely would be present; however, we would still recommend no further MEG activity of this type.

If significant artifacts were found in the calibration, then we would also recommend no further MEG activity of this type. In all cases, we would declare that the observed effect in the original study was most likely due to artifact.

2.2 Experiment Blocks

Since we have covered the cases under which "effects" were seen in the various controls, we assume, in this section, that the tests of hypotheses 3 and 4 in Table 2 were not significant There are three cases of interest, each of which is described below.

2.2.1 Significant Remote Stimuli; Not Significant Pseudo Stimuli

Suppose that at the 95% confidence level, statistically significant deviations are observed for the RS summed across all 12 receivers and not for the PS. Consider two cases:

(1) A t-test for the effect sizes of the RS and after-block controls was significant (i.e., Hypothesis 5). In this case, we have replicated the earlier study, and would recommend extensive follow-on work be done in accordance with the advice of the SOC.

We would conduct a X^2 test for homogeneity of effect size and recommend additional MEG work for the "outliers."

(2) A t-test for the means of the RS and after-block control distributions showed no significance. We would recommend that further work might be appropriate depending upon the individual tests for homogeneity and the magnitude of the differences between the means. In this case, a judgment would be necessary and there would be no "exact" guidelines.

2.2.2 Significant Pseudo Stimuli: Not Significant Remote Stimuli

Suppose that at the 95% confidence level, statistically significant deviations were observed for the PS summed across all 12 receivers and not for the RS (i.e., Hypotheses 2 and 1, respectively). For this discussion, we assume that no "effects" were seen in the calibration studies, thus the interpretation of this

outcome is difficult. We would recommend additional physical calibration of the MEG system and further experimental trials that are specifically designed to understand the source of the PS deviations.

2.2.3 Significant Pseudo Stimuli: Significant Remote Stimuli

Suppose that at the 95% confidence level, statistically significant deviations were observed for the PS summed across all 12 receivers and for the RS (i.e., Hypotheses 2 and 1, respectively). As above, we assume that no "effects" were seen in the calibration studies. One interpretation would be that the stimulus generator and/or the HP control computer was the source of the stimulation rather than the remote TV-monitor. In this case, since this outcome was the one observed in the first study, we would have replicated that result. In this circumstance, we would recommend a specific modification to the experiment apparatus to control for this type of effect. Then the study should be repeated in its entirety.

V REVIEW OF STATISTICAL POWER

The power of a statistical measure is defined as the probability of a significant observation *given* that an effect hypothesis (H_1) is true. Define the value of a dependent variable as X. Then, given that the null hypothesis (H_0) is true, a significant observation, x, is defined as one in which the probability of observing

$$x \geq \mu_0 + 1.645\sigma_0,$$

where μ_0 and σ_0 are the mean and standard deviation of the parent H_0 distribution, is less than or equal to 0.05.

Figure 3 shows these definitions in graphical form under the assumption of normality. The *Z-Score* is a normalized representation of the dependent variable and is given by:

$$z = \frac{(x - \mu_0)}{\sigma_0},$$

where x is the value of the dependent variable and μ_0 and σ_0 are the mean and standard deviation, respectively, of the parent distribution under H_0, and z_c is the minimum value (i.e., 1.645) required for significance (one-tailed). The mean of z under H_0 is zero. The mean and standard deviation of z under H_1 are μ_{AC} and σ_{AC}, respectively.

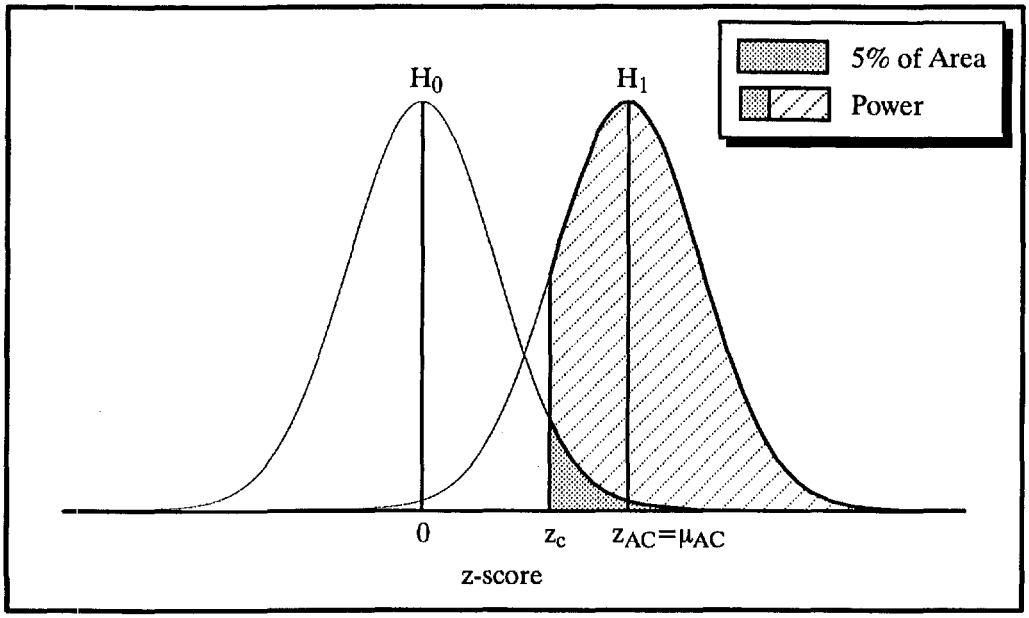

Figure 3. Normal Representation of Statistical Power

In general the effect size, ε, may be defined as:

$$\varepsilon = \frac{z}{\sqrt{n}}, \tag{3}$$

where n is the sample size. Let ε_{AC} be the empirically derived effect size for anomalous cognition (AC). Then $z_{AC} = \mu_{AC}$ in Figure 3 is computed from Equation 3. From Figure 3 we see that power is defined by:

$$\text{Power} = \frac{1}{\sigma_{AC}\sqrt{2\pi}} \int_{z_C}^{\infty} e^{-0.5\left(\frac{\varsigma - \mu_{AC}}{\sigma_{AC}}\right)^2} d\varsigma . \tag{4}$$

Let

$$z = \frac{\varsigma - \mu_{AC}}{\sigma_{AC}}.$$

Then Equation 4 becomes

$$\text{Power} = \frac{1}{\sqrt{2\pi}} \int_{z'_c}^{\infty} e^{-0.5z^2} dz, \quad \text{where } z'_c = \frac{z_c - \mu_{AC}}{\sigma_{AC}}. \tag{5}$$

For planning purposes, it is convenient to invert Equation 5 to determine the number of trials that are necessary to achieve a given power under the H_1 hypothesis. If we define z(P) to be the z-score associated with a power, P, then the number of trials required is given by:

$$n = \frac{4z^2(P)}{\varepsilon_{AC}^2}, \tag{6}$$

where ε_{AC} is the estimated mean value for the effect size under H_1. Figure 4 shows the power, calculated from Equation 5, for various effect sizes for $z_c = 1.645$.

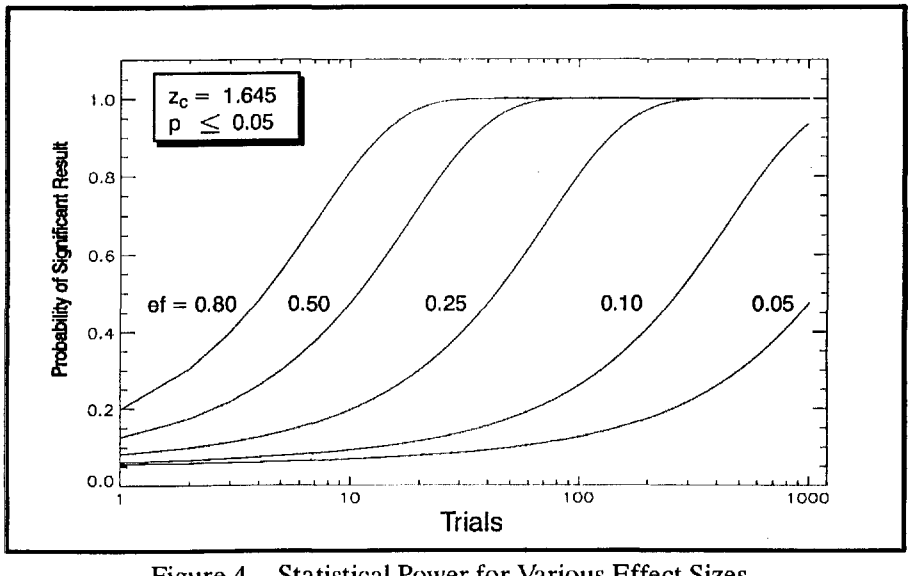

Figure 4. Statistical Power for Various Effect Sizes

VI RECEIVER INFORMATION

Introduction

Here, we provide a brief, non-technical overview of the MEG experiment. After reading this, please feel free to direct any questions you might have to Ed May, Wanda Luke, or Nevin Lantz. We have kept the technical jargon to a minimum; however, the following terms may be helpful:

- **Anomalous Cognition (AC).** A form of information transfer in which all known sensorial stimuli are absent. This includes phenomena that are described in the parapsychological literature as extra-sensory perception, telepathy, clairvoyance, and precognition.
- **Magnetoencephalograph (MEG).** A device consisting of sensors used to measure, in three-dimensional space, the magnetic fields produced by neuronal electric currents in the cortex of the brain.

Why this experiment?

The purpose of this experiment is to replicate an earlier study in which there appeared to be a physiological response correlated to AC. This experiment is important not only because it may identify a part of the brain that is directly associated with AC, but also because it may move the scientific study of AC into the mainstream of the science.

What is magnetoencephalography?

Magnetoencephalography is a noninvasive technique use to measure the magnetic fields that result from electrochemical currents produced by active neurons in the cortex of the brain. That is, neurons that participate in a given activity (e.g., responding to a flash of light) communicate between themselves and ultimately to other parts of the body by a complex combination of electrical signals and chemical interactions. This activity produces magnetic fields that can be sensed externally by a MEG.

What does this experiment consist of?

The major elements in the experiment are as follows:

- **Stimuli.** A 0.1-second presentation of a grating that looks like a 5-cm-square white picket fence.
- **Receiver.** An individual who, without using known senses, attempts to perceive information about the stimuli.
- **Sender.** An individual who, while looking directly at the stimuli, tries to transmit their characteristics to the receiver.
- **Run.** Two minutes of data collection.
- **Block.** Ten runs.

The receiver will be monitored by a MEG in a specially designed magnetically shielded room while a sender, who is located down the hall, is looking at the flashing stimuli.

What will be expected of me?

What is expected of you during the experiment depends on whether you will be a receiver or sender; you may be asked to serve as both. You need not memorize all of this information now, because we will review the instructions at the time of the experiment.

Receiver

You will be asked to remove all metal from your person (e.g., belt buckles, jewelry, coins). Women may want to avoid wearing under-wire bras on days when they serve as receivers. In addition, you will be fitted with a skull cap so that we can mark the position of the MEG sensors. You will lie prone, face down on a bed-like structure beneath the MEG device. There are pillows and a large opening so that you can see and breath comfortably. The MEG will be lowered into position over the back of your head; you may feel slight pressure.

Note: At all times on the MEG table, please try to lie as motionless as possible; muscle movement can be sensed by the MEG and interferes with the brain-wave data.

The first task is to properly position the MEG. (A sender is not required for this part of the measurement.) We will place the MEG sensors at a place that corresponds to the location that produces the largest brain response to a light flash that you can physically see. All you have to do is to lie quietly, and passively observe the random light flashes. Initially, a number of runs that last a few minutes might be necessary to identify the proper location. Once identified, it will be marked on a skull cap that will only be used by you.

Each day that you visit the laboratory, we will position the MEG according to the cap markings and perform a brief run to confirm the proper position.

During your visit to the laboratory, you will be a receiver for one block a day for five days. An experiment block consists of ten runs of 2 minutes each, during which six to twelve stimuli will be shown to your sender. As before, you should relax with your eyes closed. After five runs, an experimenter will quietly enter the room and check the position of the sensor. If needed, it will be readjusted at that time.

We are not sure how you can become an accomplished AC receiver. There are a few strategies that have been successful in the past. Choose one or invent your own, but stay with the same strategy throughout the entire block.

- **Passive Attention.** Before a run begins, give yourself the mental suggestion to "observe" the remote stimuli. When the run begins (i.e., you will be told over an intercom), relax and do not "try" to sense the signal directly. Rather, be aware in the back of your mind that you want to "receive" the AC signal.
- **Nothing.** In this technique, you simply relax and "let it happen."
- **Active Attention.** This strategy involves choosing a target (i.e., either the sender, the remote stimuli, or both), and concentrating on that mental image throughout the 2-minute run.

Sender

The sender will simply sit in the isolated room and concentrate on the occasional stimuli. They should appear relatively infrequently. You may attempt to "project" what you see to the receiver using any mental strategy you wish.

VII GLOSSARY

Not all the terms defined below are germane to the MEG study, but they are included here for completeness. In a typical anomalous mental phenomena (AMP) task, we define:

- Anomalous Cognition (AC)—A form of information transfer in which all known sensorial stimuli are absent. That is, some individuals are able to gain access, by an as yet unknown process, to information that is not available to the known sensorial channels.
- Receiver—An individual who attempts to perceive and report information about a target.
- Agent—An individual who attempts to influence a target system.
- Target—An item that is the focus of an AMP task (e.g., person, place, thing, event).
- Target Designation—A method by which a specific target, against the backdrop of all other possible targets, is identified to the receiver (e.g., geographical coordinates).
- Sender/Beacon—An individual who, while receiving direct sensorial stimuli from an intended target, acts as a putative transmitter to the receiver.
- Monitor—An individual who monitors an AC session to facilitate data collection.
- Session—A time period during which AC data is collected.
- Protocol—A template for conducting a structured data collection session.
- Response—Material that is produced during an AC session in response to the intended target.
- Feedback—After a response has been secured, information about the intended target is displayed to the receiver.
- Analyst—An individual who provides a quantitative measure of AC.
- Specialty—A given receiver's ability to be particularly successful with a given class of targets (e.g., people as opposed to buildings).

REFERENCES

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2. E. C. May, (Consultant), R. Targ, and H. E. Puthoff, SRI International, "Possible EEG Correlates To Remote Stimuli Under Conditions of Sensory Shielding, "Electro 77 Professional Program, Special Session: The State of the Art in Psychic Research, IEEE, New York, NY (April 1977).
3. E. C. May, W. L. W. Luke, V. V. Trask, and T. J. Frivold, "Observation of Neuromagnetic Fields in Response to Remote Stimuli," *The Proceedings of the Presented Papers of the Parapsychological Association 33rd Annual Convention*, National 4-H Center, Chevy Chase, MD (August 1990).

APPENDIX

This appendix contains the full reprints of the following three papers:

(1) "EEG Spectrum Analysis Techniques Applied to the Problem of Psi Phenomena"
(2) "Possible EEG Correlates To Remote Stimuli Under Conditions of Sensory Shielding"
(3) "Observation of Neuromagnetic Fields in Response to Remote Stimuli"

EEG SPECTRUM ANALYSIS TECHNIQUES APPLIED TO THE PROBLEM OF PSI PHENOMENA[1, 3]

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ABSTRACT

Electroencephalographic techniques were used to study unusual sensory capabilities. One S, the "sender," of a pair of Ss was stimulated with 10 sec duration trains of flicker at 6 or 16 fps, randomly interspersed with periods of no flicker. EEGs were recorded from another S, the "receiver," to determine if EEG driving or alpha block would be evident on trials when the sender was stimulated, compared to when the sender was not stimulated. Differential alpha block on control and stimulus trials was observed reliably in one receiver, indicating some information transfer. The S's overt indications of which stimulus occurred were not different from what would be expected by chance. The physical parameters by which the EEG effect was mediated were not determined.

INTRODUCTION

The suggestion has been made previously that communication through unidentified channels (so-called telepathy or clairvoyance) might be detected by the measurement of physiological responses when overt responses (e.g., verbalizations) provide no evidence of such communications. For example, Dean (1966) reported that plethysomographic responses could be used in such a manner, and Tart (1963) observed significant changes in a measure of EEG "complexity" in naive Ss when Tart (or a resistor) was, unknown to the Ss, given intense electric shock. The Ss' *overt* responses indicated no awareness of the occurrence of shocks. Duane and Behrendt (1965) reported on the occurrence of extrasensory EEG induction between identical twins, and Kamiya, Lindsley, Pribram, Silverman, Walter, and others have suggested that EEG responses such as evoked potentials (EPs), spontaneous EEG, and the contingent negative variation (CNV) might be sensitive indicators of communication not mediated by usual sensory processes (See Cavanna, 1970).

Silverman and Buchsbaum (1970) attempted, without success, to detect EP changes in one S while another S was stimulated with a single stroboscopic flash. Kamiya (1970) suggested that because of the unknown temporal characteristics of psi phenomena, it might be more appropriate to use repetitive bursts of light for several minutes to increase the probability of detecting information transfer.

An investigation was undertaken by us to determine whether augmented perception could be evidenced by CNVs or by the spontaneous EEG, using averaging techniques and spectral analysis of occipital EEGs. The design of the investigation was based partly on a previous, but unreplicated, result concerning the CNV in one S, and on the fact that normal individuals exhibit alpha desynchronization and photic driving when directly stimulated with flashing lights.* It was assumed that psi mediated perception would result in EEG changes similar to those produced by normal stimulation—i.e., evidence of photic driving and/or alpha desynchronization was sought in one S when another was stimulated.

CNVs were obtained just before a period when a second stimulus might or might not appear to determine whether characteristics of the CNV were predictive of the occurrence or non-occurrence of the second stimulus.

METHODS

Four female and two male adult Ss were studied. One S, the receiver, was seated in a standard Industrial Acoustics EEG chamber that had been used in other EEG investigations (e.g., Rebert and Sperry, 1972). Recordings were made from the vertex and occipital pole on the midline with Grass and Beckman Ag-AgCl electrodes, referenced to linked mastoids. Potentials

* To one S not included in this investigation, a warning tone followed by a train of flashes or a null period were presented to determine if he would generate CNVs. They occurred prior to flashes but not before null trials. The effect was not replicated in that S, but influenced the design of the present study.

were amplified with Grass 5P-1 preamplifiers and associated driver amplifiers in a Grass Model 5 polygraph. The 0.8 tc low frequency setting, with an actual time constant of 2.5 sec., was used for the vertex recording, whereas the 0.1 tc low frequency setting was used for the occipital lead. Upper frequency was limited by the 120 per sec mechanical chopper.

Identical measures were obtained simultaneously from a second S, the sender, who was seated in another room approximately 7 meters from the EEG chamber. A second Grass Model 5 polygraph was used for these recordings. Amplified scalp potentials from the two Ss were recorded on magnetic tape with an Ampex SP-300 recorder (no cross talk was detectable). Because of channel limitations on the SP-300, electro-oculograms were not measured.

Ss were run in pairs. Usually, one would act first as receiver, then as sender. A Grass PS-2 photostimulator was used to present flash trains of 10 sec duration (20 sec in one session) to the sender at 6 or 16 fps. On any given trial during each experimental set of 36 trials, either one of the flicker trains could be presented or an equivalent null (no flash) period would occur. The null period constituted a within-S control condition. Twelve trials each of the 0, 6, or 16 fps conditions were given in pseudo random order, generated beforehand by the experimenter.

On each trial both the sender and receiver were presented a 100 msec, 1 KHz tone burst 1 sec before onset of the photostimulus to provide the receiver information about *when* a flash train (or null period) would occur, and to induce CNVs. After termination of the flash train or null period, the receiver was cued by a click over an intercom to guess whether 0, 6, or 16 fps had been presented to the sender. The receiver tapped a telegraph key once, twice, or three times to so indicate.

Time-locked digitizing of EEGs was done off-line with a Linc-8 computer. Eight sec of occipital EEGs associated with the midportion of the 10 sec flash trains or null periods were stored in two consecutive 4 sec epochs on two consecutive Linc tape blocks. Epochs of 2.5 sec duration, beginning 1800 msec before the flicker, were obtained from the vertex derivation for CNV analysis. CNVs were scored in a typical manner—i.e., the average amplitude 250 msec before the second event (flicker or null period) was compared to a baseline established before the warning stimulus.

The occipital EEG was quantified by spectral analysis using the Fast Fourier transform. Spectra covered the frequency range of 0 to 25 Hz.

Alpha activity was scored by first identifying alpha bands for each S independently by averaging across spectra from individual trials, and determining low and high alpha limits from the average with a cursor program. For any given S, the same limits were used in all analyses. The decimal value of each data point in the alpha band was printed out for spectra of each trial and four scores were derived. Average power = the average value of all the data points within the alpha band. Peak power = the maximum value within the the alpha band on each trial. Peak position = the ordinal position of the largest value in the alpha band (an indication of alpha frequency). Synchrony = the ratio of peak power to average power.

RESULTS

Overt responses indicating the receiver's conscious estimates of the type of stimulus presented to the sender (0, 6, 16 fps) did not differ from chance. Also, no differences in CNVs associated with the occurrence or nonoccurrence of flicker were found—i.e., the CNV was not predictive of imminent flicker stimulation or its absence in senders or receivers.

Data from the second 4 sec occipital EEG epoch was selected for primary analysis on the assumption

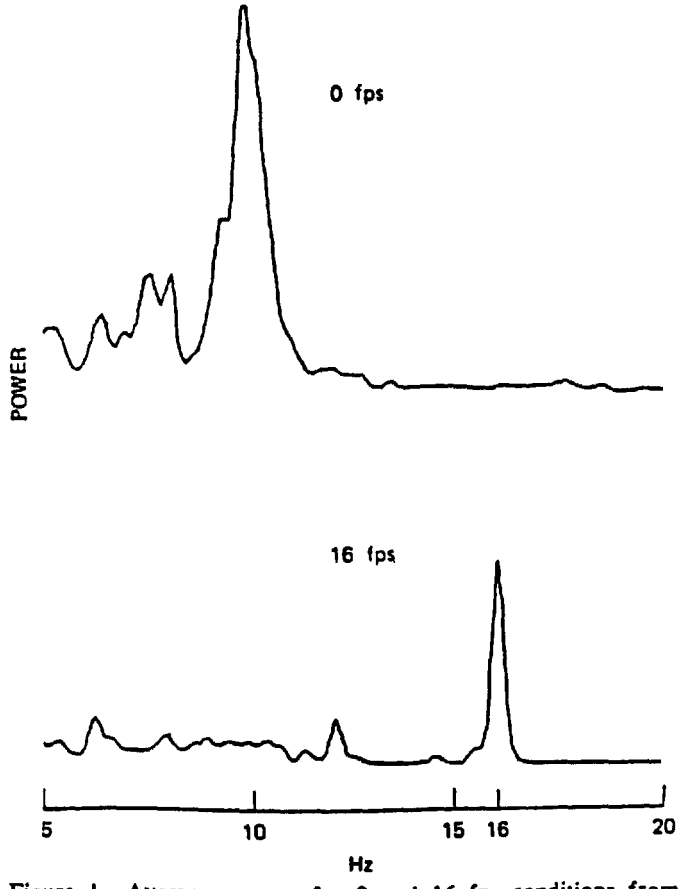

Figure 1 Average spectra for 0 and 16 fps conditions from one sender showing alpha blocking and photic driving in response to flicker.

that considerable time might be involved in the perceptual processes under consideration, and to minimize the EEG desynchronizing action of the warning cue.

Photic driving was obtained when the Ss were directly stimulated with the strobe. Examples of spectra associated with 0 and 16 fps trials from one S acting as sender are shown in Figure 1. The examples are averages of 12 spectra.

No evidence of EEG driving at either 6 or 16 Hz, or other frequencies was obtained from any receiver.

For purposes of visualizing results, spectra were

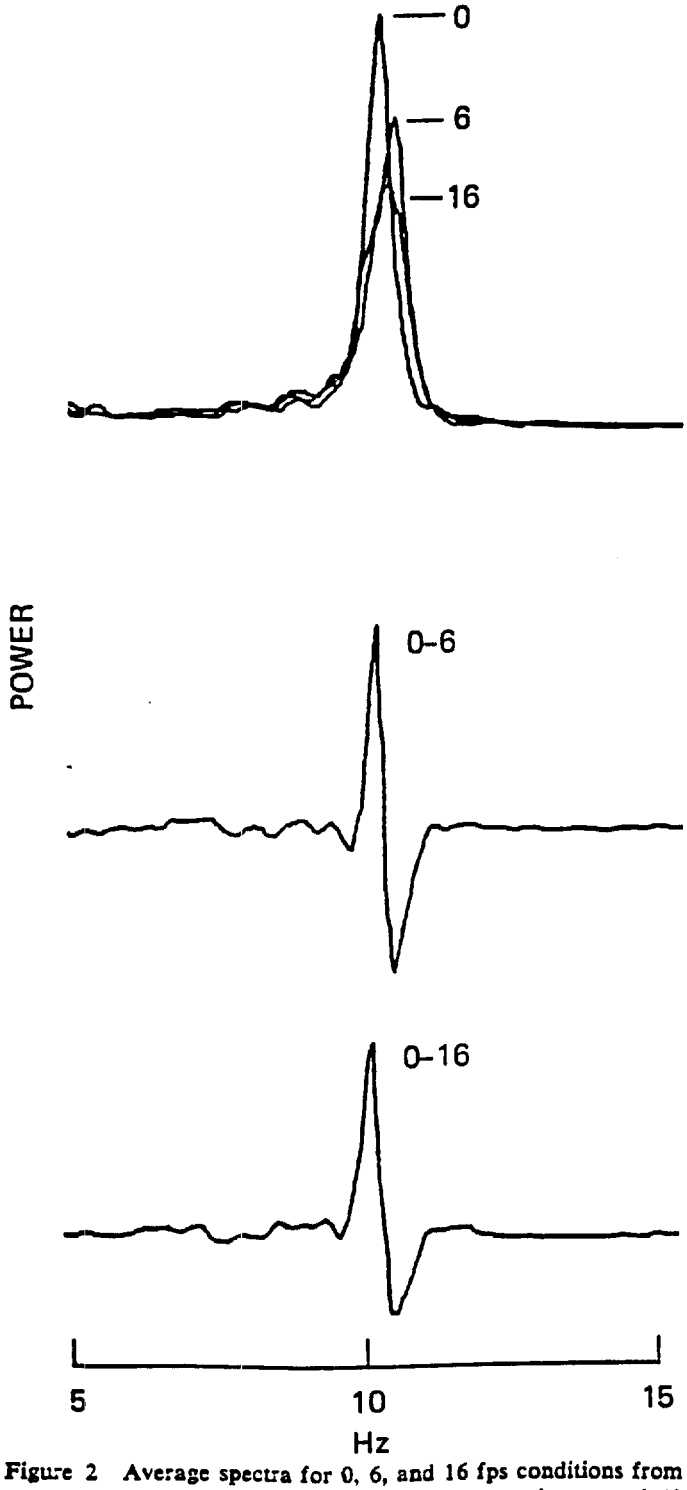

Figure 2 Average spectra for 0, 6, and 16 fps conditions from one receiver and differences between the control (0 fps) trials and trials with flicker.

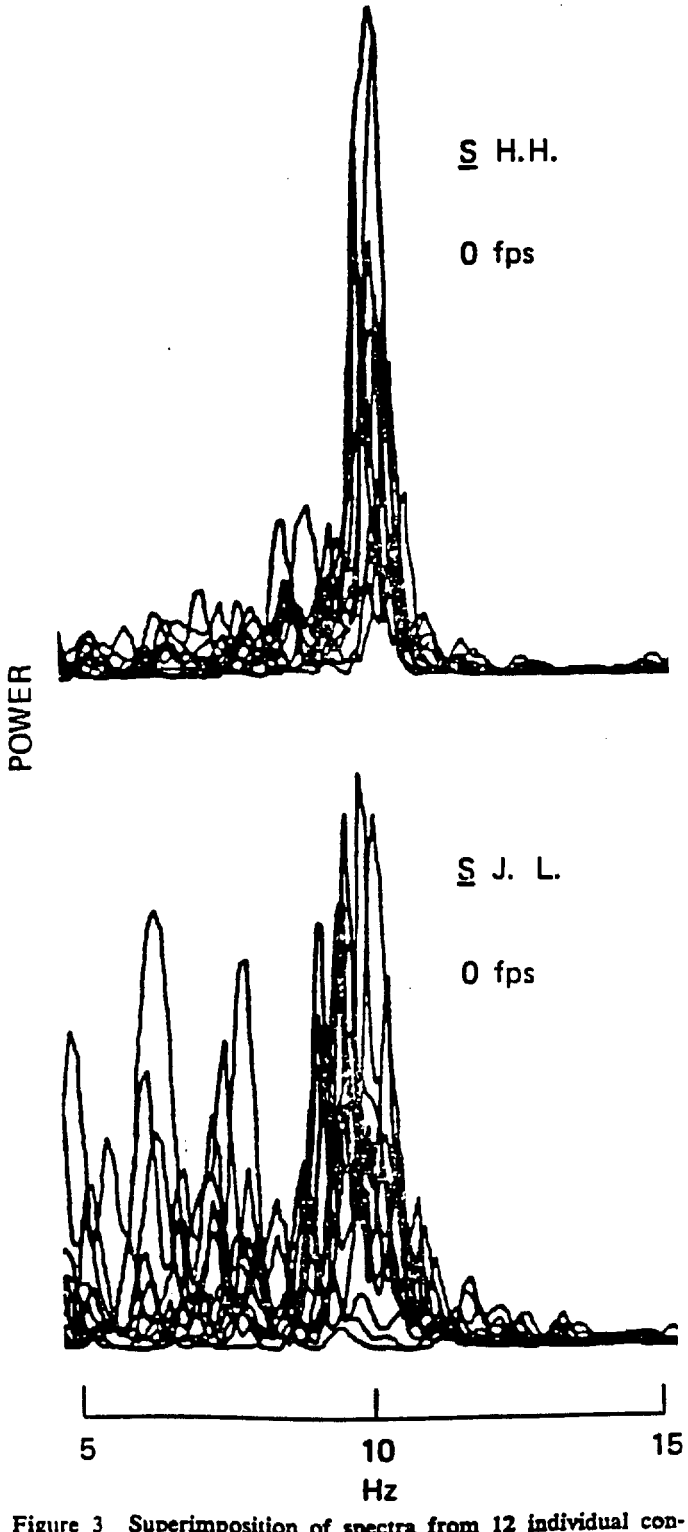

Figure 3 Superimposition of spectra from 12 individual control trials in two *S*s, showing the great consistency of *S* H.H.'s alpha activity.

averaged, and averaged spectra associated with flicker trials were algebraically subtracted from null trials by computer. Alterations of activity in the alpha range were indicated by that procedure in some Ss. Examples from one receiver of such spectra and their differences are shown in Figure 2.

Three Ss exhibited rather poor alpha activity and evidenced no obvious differences among conditions so their data were not subject to further detailed analysis. Another S who was run on several occasions sometimes showed well-developed alpha, but difference scores among conditions were very inconsistent. Of the two remaining Ss, one had relatively robust alpha and there was an apparent increase of alpha when the sender was stimulated with 6 fps. However, preliminary statistical analysis of the single point of maximum difference between the 0 and 6 fps spectra showed the difference to be nonsignificant ($t = 0.92$).

The remaining S had extremely well-developed alpha of high amplitude and stability. Figure 3 contrasts this S with another who had relatively good alpha. Because of the difference between null and flicker trials suggested

TABLE 1

Average Values (12 trials) of Four EEG Spectrum Measures in Eight Experimental Sets (Subject H.H.) (Second 4 sec EEG Epoch) Flash Frequency (fps)

SESSION	SET	0		6		16		
AVERAGE POWER (A)		$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	SENDER
1	1	94.8	50.6	84.1	33.0	76.8	37.7	J.L.
2	1	41.3	16.7	45.5	17.4	37.0	21.4	R.T.
	2	25.1	21.3	35.7	20.8	28.2	21.4	None (informed)
	3	54.2	31.4	55.3	14.9	44.8	18.5	J.L.
	4	56.8	28.9	50.9	36.0	32.3	19.6	J.L.
3	1	39.8	33.4	24.9	20.2	30.3	32.8	R.T.
	2	86.0	60.5	53.0	48.6	52.1	51.2	None (uninformed)
	3	64.5	32.4	76.0	44.4	68.6	34.3	R.T. (feedback)
PEAK POWER (P)								
1	1	357.7	246.6	392.2	159.8	289.6	192.7	
2	1	160.7	68.1	161.0	85.7	125.0	81.4	
	2	87.5	86.9	95.7	70.5	81.7	61.6	
	3	191.4	134.1	170.5	63.4	149.3	60.4	
	4	240.6	138.7	178.0	174.7	104.6	77.4	
3	1	145.2	145.0	74.2	73.3	122.1	153.5	
	2	318.1	215.6	180.6	167.8	202.3	224.3	
	3	240.8	186.0	270.3	198.4	217.3	123.0	
PEAK POSITION								
1	1	9.3	1.1	10.2	2.5	9.5	2.2	
2	1	9.6	2.3	7.3	2.7	8.7	1.2	
	2	7.6	3.3	7.5	2.8	8.6	4.1	
	3	7.7	1.6	9.0	1.9	8.0	2.1	
	4	7.8	2.6	8.3	3.7	7.2	3.1	
3	1	7.8	3.9	8.8	4.4	9.6	3.7	
	2	8.3	3.1	6.0	3.3	7.0	3.8	
	3	9.6	2.0	8.9	3.7	9.2	3.5	
SYNCHRONY (P/A)								
1	1	3.5	1.1	3.8	0.6	3.5	0.9	
2	1	3.8	0.8	3.5	0.9	3.3	0.6	
	2	3.3	0.8	2.9	0.8	3.1	0.5	
	3	3.4	1.0	3.1	1.0	3.4	0.8	
	4	4.2	0.7	3.3	1.1	3.1	0.7	
3	1	3.5	1.1	3.0	1.0	3.3	1.4	
	2	3.3	1.3	3.5	0.7	3.7	0.9	
	3	3.5	1.0	3.4	0.8	3.1	0.5	

by the data shown in Figure 2 this S was tested in two additional experimental sessions of 4 and 3 sets of 36 trials respectively. Her sessions were done on 8-3-73, 11-12-73, and 11-29-73.

Three sets of experiments with this S were atypical in the following ways. On session 2, set 2, the sender was removed from the experiment *with* the knowledge of the receiver. On session 3, set 2, the sender was removed *without* the knowledge of the receiver. On session 3, set 3, the sender was present, but verbal feedback regarding the actual flash frequency or null period was given the receiver after each trial. During all of session 3 the flicker was 20 sec rather than 10 sec in duration.

Mean values for the four scores obtained from each experimental set for this S are given in Table 1. Peak power associated with the 16 fps condition was less than that associated with control (null) trials in all eight experimental sets. The 6 fps condition showed less peak power in four of the eight sets.

Although obtained from a single S, there was no rationale for matching particular null trials with particular flash trials so the individual trial scores were treated as independent variables and a two-tailed t approximation to the nonparametric randomization test was used to evaluate the data (Siegel, 1956). The five comparable sets of data (all those including a sender, except the one with verbal feedback) formed the primary basis for statistical analyses. Means and standard deviations over these five sets for the several scores and conditions are presented in Table 2.

For the five comparable sets, average power and peak power in the second EEG epoch were significantly

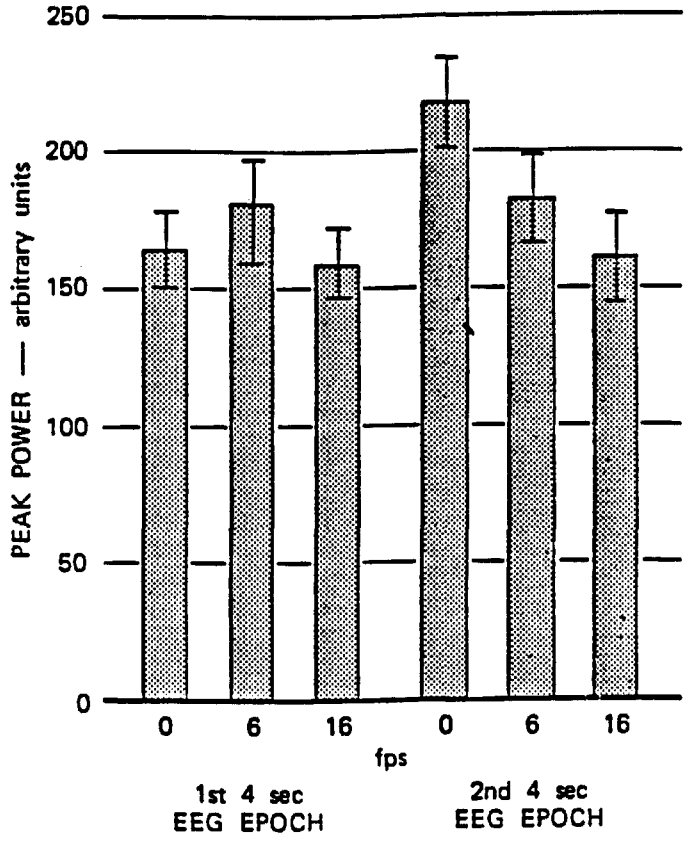

Figure 4 Average peak power in the three stimulus conditions for consecutive EEG epochs, in *S* H.H.

less in this receiver when the sender was stimulated with 16 fps than when no flashes occurred ($t_a = 2.09$, df = 118, $p < .05$; $t_p = 2.16$, df = 118, $p < .05$). The 6 fps condition did not differ significantly from the control condition in terms of any measure. Relative peak power in the three conditions based on all the data are displayed graphically in Figure 4. When all

TABLE 2

Overall Average Values for 5 Comparable Sets of Four EEG Spectrum Measures (Subject H.H.)

		EEG Block 1			EEG Block 2		
	FPS	0	6	16	0	6	16
	n	60	56	60	60	56	60
AVERAGE POWER	$\bar{X}$	46.8	48.5	45.0	57.6	51.9	44.2*
	σ	34.2	35.8	30.7	38.4	32.3	31.3
PEAK POWER	$\bar{X}$	158.7	166.6	151.5	219.1	183.4	158.1*
	σ	127.1	143.7	121.1	170.3	147.2	137.7
PEAK POSITION	$\bar{X}$	8.0	8.4	8.2	8.5	8.7	8.6
	σ	3.4	2.8	3.2	2.6	3.3	2.7
SYNCHRONY	$\bar{X}$	3.28	3.26	3.31	3.67	3.37	3.33
	σ	1.03	0.86	0.91	0.97	0.94	1.40

* significantly different from 0 fps ($p < .05$)

characteristics of the stimulus train. Interpreting the lesser EEG effect in the 6 fps condition as due to a less energetic stimulus suggests that the S may have been unusually sensitive to minute magnetic or static fields that might have been differentially produced in her environment by the two stimulus frequencies. This suggestion is reinforced by the fact that no sender was required to obtain the alpha suppression. The sender was absent during session 3, set 2 (Table 1) without the receiver's knowledge, yet a large effect on the EEG was still produced. A similar result was reported by Tart (1963) who also obtained effects in a "control" condition where a resistor rather than a person was shocked. However, our S's inability to overtly indicate, above chance levels, whether null or stimulus trials occurred indicates that *supraliminal* cues associated with flicker were not responsible for the effect. Also, high gain recording of electrical noise in the environment of the S revealed no energy increment associated with the onset of flicker. Recordings from saline with the introduction of a 50μV, 10 Hz signal also indicated that the alpha reduction was not a consequence of system artifacts modulating the alpha signal.

This investigation describes a procedure that appeared to be a sensitive technique for detecting the occurrence of information transfer that was not mediated by physical parameters that could be easily identified. This is not to suggest that the effect seen was in any way unnatural—only that it suggested some modality of extreme perceptual sensitivity that is unidentified and unexplained. Data from just one subject can only be suggestive, but this study, using rigorous and objective evaluative techniques, supplements other previous studies with similar suggestions (Dean, 1966; Tart, 1963). Such findings, if valid, have important implications for theories of perception and nervous system functions. However, the investigation of unusual sensory capacities has always been fraught with unreliability and our findings certainly need replication and extension. The use of longer foreperiod, and multichannel recording would be useful procedural alterations of our method. Cerebral localization of the effect would inherently involve a control against artifactual production of the effect.

KEYWORDS

Perception, psi, EEG, alpha, spectrum.

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FOOTNOTES

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[2]Current professional address for private practice is 555 Middlefield Road. Palo Alto, California.

[3]A brief summary of this work was reported in *Nature*, Oct. 18, 1974.

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POSSIBLE EEG CORRELATES TO REMOTE STIMULI UNDER CONDITIONS OF SENSORY SHIELDING

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ABSTRACT

We have investigated the ability of certain individuals to perceive remote (faint) stimuli at a noncognitive level of awareness. To investigate this we have looked for systematic changes in a subject's brainwave (EEG) production occurring at the same time as light flashes are generated on a random schedule in a remote laboratory. Although we have found in this investigation that significant correlations appear to exist between the times of light flashes and the times of brainwave alterations, we consider these data to be only suggestive, with a definitive result requiring further experimentation.

INTRODUCTION

In a number of laboratories evidence has been obtained indicating the existence of an as-yet-unidentified channel wherein information is coupled from remote electromagnetic stimuli to the human nervous system as indicated by physiological response, even though overt responses such as verbalizations or key presses provide no evidence for such information transfer. Physiological measures have included plethysmographic response[1] and EEG activity.[2,3] Kamiya, Lindsley, Pribram, Silverman, Walter, and others have suggested that a whole range of EEG responses such as evoked potentials (EPs), spontaneous EEG, and the contingent negative variation (CNV) might be sensitive indicators of the detection of remote stimuli not mediated by usual sensory processes.[4]

A pilot study was therefore undertaken at SRI to determine whether EEG activity could be used as a reliable indicator of information transmission between an isolated subject and a remote stimulus. Following earlier work of others, we assumed that perception could be indicated by such a measure even in the absence of verbal or other overt indicators.

To aid in selecting a stimulus, we noted that Silverman and Buchsbaum attempted, without success, to detect EP changes in a subject in response to a single stroboscopic flash stimulus observed by another subject.[5] Kamiya suggested that because of the unknown temporal characteristics of the information channel, it might be more appropriate to use repetitive bursts of light to increase the probability of detecting information transfer.[6] Therefore, in our study we chose to use repetitive light bursts as stimuli.[7-9]

PILOT STUDY AT SRI

In the design of the study it was assumed that the application of remote stimuli would result in responses similar to those obtained under conditions of direct stimulation. For example, when normal subjects are stimulated with a flashing light, their EEG typically shows a decrease in the amplitude of the resting rhythm and a driving of the brain waves at the frequency of the flashes.[10] We hypothesized that if we stimulated one subject in this manner (a putative sender), the EEG of another subject in a remote room with no flash present (a receiver), might show changes in alpha (8-13 Hz) activity, and possibly EEG driving similar to that of the sender, either by means of coupling to the sender's EEG, or by coupling directly to the stimulus.

We informed our subject that at certain times a light was to be flashed in a sender's eyes in a distant room, and if the subject perceived that event, consciously or unconsciously, it might be evident from changes in his EEG output. The receiver was seated in a visually opaque, acoustically and electrically shielded double-walled steel room located approximately 7 m from the sender's room.

We initially worked with four female and two male volunteer subjects. These were designated "receivers." The senders were either other subjects or the experimenters. We decided beforehand to run one or two sessions of 36 trials each with each subject in this selection procedure, and to do a more extensive study with any subject whose results were positive.

A Grass PS-2 photostimulator placed about 1 m in front of the sender was used to present flash trains of 10 s duration. The receiver's EEG activity from the occipital region (Oz), referenced to linked mastoids, was amplified with a Grass 5P-1 preamplifier and associated driver amplifier with a bandpass of 1-120 Hz. The EEG data were recorded on magnetic tape with an Ampex SP 300 recorder.

On each trial, a tone burst of fixed frequency was presented to both sender and receiver and was followed in one second by either a 10 s train of flashes or a null flash interval presented to the sender. Thirty-six such trials were given in an experimental session, consisting

*Consultant to SRI.

of 12 null trails--no flashes following the tone--12 trials of flashes at 6 f.p.s. and 12 trials of flashes at 16 f.p.s., all randomly intermixed, determined by entries from a table of random numbers. Each of the trials consisted of an 11-s EEG epoch. The last 4 s of the epoch were selected for analysis to minimize the desynchronizing action of the warning cue. This 4-s segment was subjected to Fourier analysis on a LINC 8 computer.

Spectrum analyses gave no evidence of EEG driving in any receiver, although in control runs the receivers did exhibit driving when physically stimulated with the flashes. But of the six subjects studied initially, one subject showed a consistent alpha blocking effect. We therefore undertook further study with this subject. Of our six subjects, this one had by far the most monochromatic EEG spectrum. Figure 1 shows a typical occipital EEG spectrum of this subject.

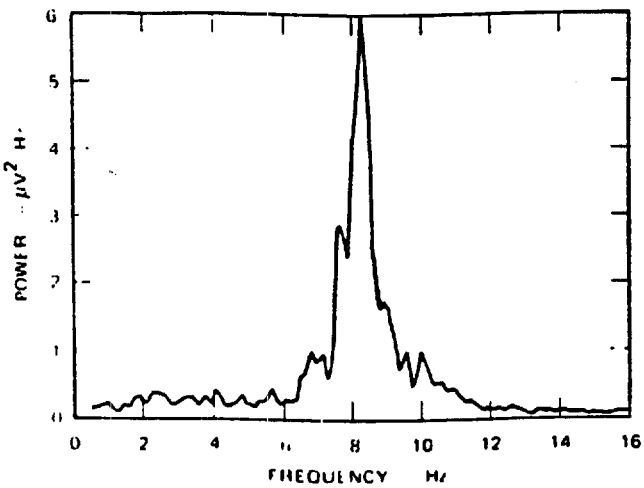

FIGURE 1 TYPICAL POWER SPECTRUM AVERAGED OVER TWENTY 8-SECOND EPOCHS

Data from seven sets of 36 trials each were collected from this subject on three separate days. This comprised all the data collected to date with this subject under the test conditions described above. The alpha band was identified from average spectra; then scores of average power and peak power were obtained from individual trials and subjected to statistical analysis. The final analysis showed that power measures were less in the 16 f.p.s. case than in the 0 f.p.s. in all seven sets of peak power measures and in six out of seven average power measures.

Siegel's two-tailed t approximation to the nonparametric randomization test[11] was applied to the data from all sets, which included two sessions in which the sender was removed. Average power on trials associated with the occurrence of 16 f.p.s. was significantly less than when there were no flashes ($t = 2.09$, $d.f = 118$, $P < 0.04$). The second measure, peak power, was also significantly less in the 16 f.p.s. conditions than in the null condition ($t = 2.16$, $d.f. = 118$, $P < 0.03$). The average response in the 6 f.p.s. condition was in the same direction as that associated with 16 f.p.s., but the effect was not statistically significant.

As part of the experimental protocol the subject was asked to indicate conscious assessment for each trial as to which stimulus was generated. The guess was registered by the subject via one-way telegraphic communication. An analysis of these guesses has shown them to be at chance, indicating the absence of any supraliminal cueing, so arousal as evidenced by significant alpha blocking occurred only at the noncognitive level of awareness.

Several control procedures were undertaken to determine if these results were produced by system artifacts or by subtle cueing of the subject. Low level recordings were made from saline of 12 kΩ resistance in place of the subject, with and without the introduction of 10 Hz, 50 μV signals from a battery-operated generator. The standard experimental protocol was adhered to and spectral analysis of the results were carried out. There was no evidence in the spectra associated with the flash frequencies, and the 10 Hz signal was not perturbed.

In another control procedure a five foot pair of leads was draped across the subject's chair (subject absent). The leads were connected to a Grass P-5 amplifier via its high impedance input probe. The bandwidth was set 0.1 Hz to 30 kHz with a minimum gain of 200,000. The output of the amplifier was connected to one input of a C.A.T. 400C "averager." Two-second sweeps, triggered at onset of the tone, were taken once every 13 seconds for approximately two hours, for about 550 samples. No difference in noise level between the fore-period and the onset of flicker was observed.

REPLICATION STUDIES AT LANGLEY PORTER

The next effort was directed toward replication by an independent laboratory of the original SRI study of EEG response to remote strobelight stimuli. Arrangements for replication were made with the Langley Porter Neuropsychiatric Institute, University of California Medical Center, San Francisco.

As a special precaution against the possibility of system artifacts in the form of electromagnetic pickup from the strobelight discharge or associated electronic equipment (e.g., through the power lines), SRI developed an entirely battery-operated package for use as a stimulus generator for the EEG experimentation. It consists of a battery-driven incandescent

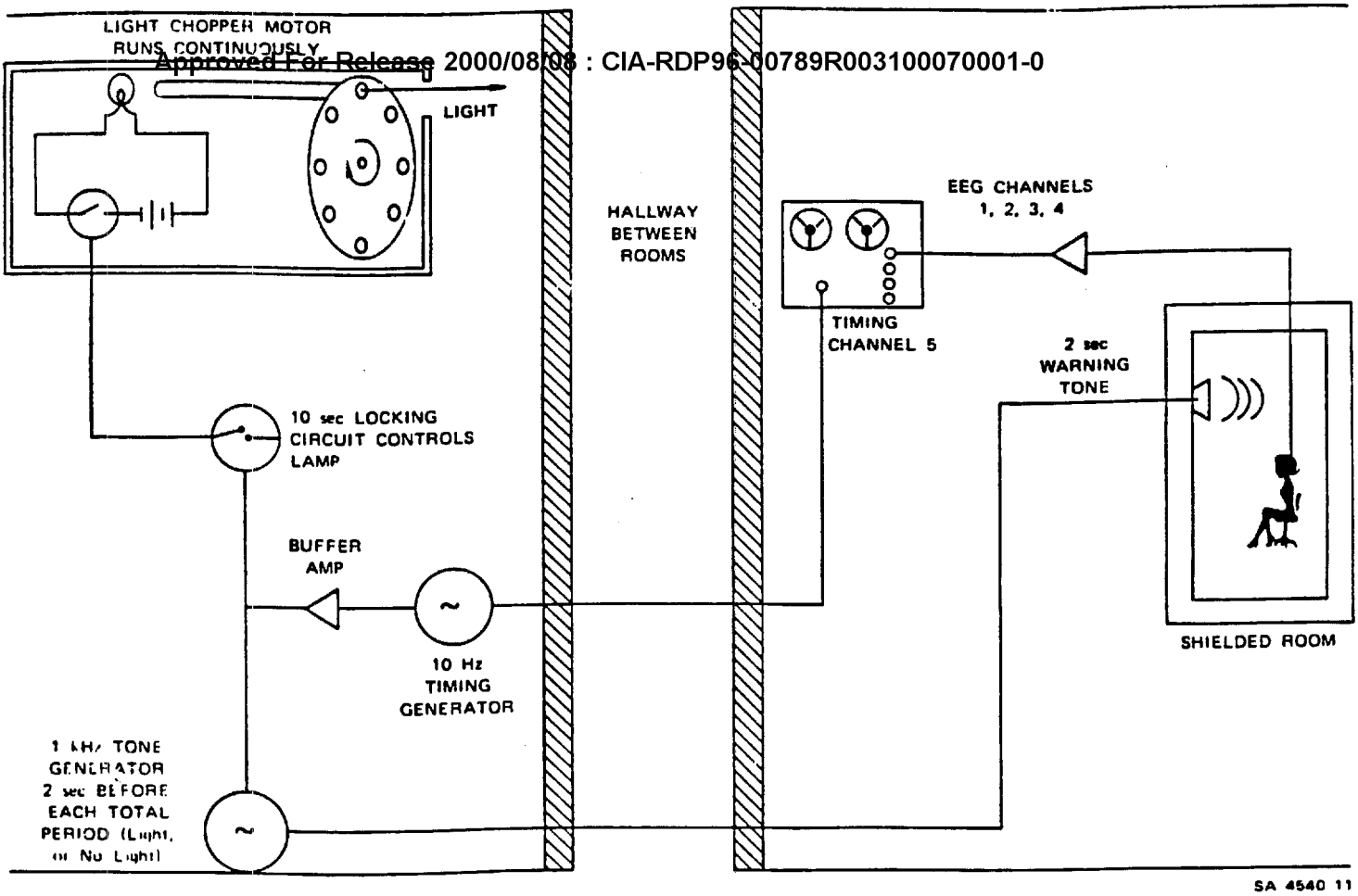

FIGURE 2 SCHEMATIC OF THE REMOTE SENSING EEG EXPERIMENT

lamp, whose CW output passes through a mechanical chopper continuously driven by a battery-driven motor as shown in Figure 2. A 10-Hz timing generator (computer triggered) controls the generation of a 1-kHz warning tone two sec before onset of the experimental period, and also drives a locking circuit that determines the presence or absence of the ten-sec light stimuli, again all battery operated. Thus everything on the left of the diagram of Figure 2 is battery operated and therefore independent of the power line system. Further, replacement of the arc-discharge strobelamp by an incandescent lamp eliminates the possibility of direct subliminal pickup of audio or electrical signals from possible transients associated with the arc discharge or associated electronics.

Description of the EEG Processor

A hardware single channel power spectrum analyzer was constructed from a commercial band-pass filter with corner frequencies of 9.0 and 12.0 Hz, and 48 dB down at 8.0 and 13.0 Hz. Analog multipliers convert the filter output to a signal proportional to in-band power. To confirm that this system is equivalent to the standard FFT analysis used in the pilot study, the analog data of the pilot study was reanalyzed, and the result was found to be consistent with the earlier analysis.

Experimental Protocol

Each experimental session consisted of 40 trials, 20 each for the 0 (no light) and 16 f.p.s. of the remote light stimulus. A trial is defined as a warning tone followed by a 10 second period consisting of a 2 second wait, and two 4 second data collection periods. The trial rate was one trial every 30 ± 1 seconds. The trial sequence was randomized subject to the following conditions: (1) in each group of 10 trials there were equal numbers of each condition, and (2) no more than three in a row of a single type were allowed. Seven 40 trial sequences were made according to this prescription and recorded separately on audio tape. During the session, trials were generated from one of these tapes and the sequence was unknown to the experimenters since the sequence tapes were

generated one month in advance of the experiments. As in the standard EEG protocol, in accordance with preestablished criteria, certain trials were deleted after the session for three reasons only: artifact, logic circuit failure, or abnormal EEG power. If a trial was rejected, a trial of the opposite stimulus condition was rejected at random from the particular set of 10 trials in question. If more than 10 trials of a given type were rejected from a session, the entire session was deleted. (This occurred twice in each experiment.)

Six channels of EEG and one logic channel taken from the sequence tape were recorded on a multiplexed FM analog tape recorder. The logic on the tape differentiated the trials between flashing and nonflashing conditions.

In pretesting the equipment, we ran the experiment using unselected subjects such as laboratory personnel, in order to test the adequacy of the experiment and to determine whether there were any correlated electronic or mechanical discharges from the apparatus. In 20 sessions of data acquisition, of 40 each (800 trials) there were no significant differences between the null and 16 Hz conditions.

RESULTS

Using the above protocol, two experiments were conducted during a three-month period. For half of the sessions, the subject was asked to press a button when she felt the light was flashing. For the six sessions (105 trials each for the 0 and 16 f.p.s. conditions when she was not asked to overtly indicate her feelings about the light, there was a slight decrease of in-band EEG power measured over the left occipital region of the brain. Similarly, for the six sessions (107 trials each for the 0 and 16 f.p.s. conditions) when she was asked to respond overtly, there was this time a significant decrease of in-band EEG power ($p \leq 0.037$, using an F ratio test derived from a two-way analysis of variance). In considering the experiment as consisting of the combined 212 trials in each stimulus condition regardless of the overt response contingency, we find a statistically significant decrease in in-band EEG power ($p < 0.011$, using F ratio test as above).

During the second experiment, three months later, a different contingency was added to determine if a "sender" was necessary to produce the effect we had observed earlier. For a given session, a random procedure (with equal trials) was used to determine if a person (called the "sender" person) would be looking at the photo-simulator. There was no one present with the photo-stimulator otherwise. For the 7 "non-sender" sessions (121 trials each for the 0 and 16 f.p.s. conditions) we find a statistically significant increase of in-band EEG power measured over the mid-occipital region of the brain ($p < 0.039$ using an F ratio test as above). During the "sender" sessions (123 trials in each stimulus condition) there was a slight increase of in-band EEG power. All together, there was a statistically significant increase of in-band EEG power when the 244 trials were analyzed regardless of "sender" condition ($p < 0.008$ using an F ratio test as above), and there was no significant difference found between "sender"/"no-sender" conditions.

For both experiments, we considered in-band EEG power for the 0-4 second and 4-8 second time periods independently to determine if the effects were time dependent. Although some of these isolated sub-intervals were statistically significant, no systematic relationship emerged. Thus the effect appears to be cumulative over the 8 seconds. The 0-8 second results are summarized in Table 1.

Table 1

SUMMARY OF RESULTS OF THE REPLICATION EXPERIMENTS SHOWING POWER MEANS AND STATISTICAL RESULTS FOR THE VARIOUS EXPERIMENTAL CONDITIONS

	Experiment I			Experiment II		
	Guessing Sessions	Non-Guessing Sessions	Combined	Sender Sessions	Non-Guessing Sessions	Combined
No light flash	957	704	832	854	766	810
Light flash	873	647	761	860	844	852
F ratio	4.39	2.20	6.47	0.017	4.33	7.03
df_1; df_2	1; 202	1; 198	1; 400	1; 232	1; 228	1; 460
$p \leq$	0.037	0.14	0.011	0.90	0.039	0.0083

DISCUSSION

Although the pilot experiment and the two replication studies all showed significant changes in EEG production correlated with the presence or absence of a remote light stimulus, the sign of the systematic change in power in the third study was opposite to that of the first two. We therefore undertook a detailed frequency analysis of the EEG data tapes from the last two experiments, since the pilot experiment had already been subjected to fast-Fourier-transform (FFT) analysis. We conjectured that the observed power change in these experiments might be the result of a very small frequency shift, which could become translated into a large amplitude change due to discriminator action of the alpha-band filter. In a chapter on alpha blocking, Kooi, in his Fundamentals of Electroencephalography says, for example, ". . . attentiveness is associated with a reduction in amplitude and an increase in average frequency of spontaneous cerebral potentials. . . The center frequency of the alpha rhythm may be influenced by the type of ongoing mental activity. Shifts in frequency may be highly consistent as two different tasks are performed alternately." The FFT analysis for the second experiment showed that the average peak EEG power occurred most often near 8 Hz, and thus fell slightly below the hardware summing window (±3 dB at 8.7-12.4 Hz) enhancing a possible discriminator effect. The FFT analysis further showed that there was an overall increase in frequency of peak power but the shift was statistically nonsignificant. This slight shift of 0.11 Hz could possibly account for the observed power increase due to the highly, nonlinear discriminator effects. In examining other portions of the spectrum for further effects, we found that systematic amplitude changes are highly dependent upon where in the frequency spectrum the power sum is taken. This is to be expected since almost all EEG phenomena are known to be strongly frequency dependent.

In the pilot study the frequency region for analysis was centered about the subject's dominant EEG output frequency with bandpass determined by the full width ten-percent power points. In the two replication studies we used hardware filters at this same frequency. FFT analysis showed clearly that if other filter bands had been chosen, significant correlations would not have been found. Thus, although our filter selection was made before the collection of any data, other experimenters might have reasonably chosen other criteria for frequency selection. Therefore, although we have found statistically significant evidence for EEG correlates to remote light flash stimuli, we consider these data to be only suggestive, with a definitive result requiring further experimentation.

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OBSERVATION OF NEUROMAGNETIC FIELDS IN RESPONSE TO REMOTE STIMULI

by

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ABSTRACT

We have conducted a conceptual replication of an SRI/Langley Porter study in which a single subject's central nervous system (CNS) responded to a remote, and isolated flashing light. The CNS activity of eight remote viewers was monitored by a seven-channel magnetoencephalograph (MEG). Visual stimuli were randomly presented to an isolated individual who acted as a "sender" while MEG data were collected from a viewer (receiver). The stimuli were 5-cm square, linear, vertical, sinusoidal gratings lasting 100 ms (remote stimuli). Time markers were randomly inserted into the data stream as control points (pseudo stimuli). The dependent variable was the root-mean-square (RMS) average phase shift of the dominant alpha frequency. Using a Monte Carlo technique to estimate p-values, we observed significant (combined across all viewers) RMS phase shifts resulting from the remote stimuli ($Z_s = 1.99, p \leq 0.024$, *effect size* $= 0.599$). Similarly, the combined statistic for the pseudo stimuli was also significant ($Z_s = 2.92, p \leq 0.002$, *effect size* $= 0.924$). The phase shifts from the remote and the pseudo stimuli are independently *not* characteristic of the data at large. This result was unexpected, and suggests that we may have observed a CNS response to an unintended stimulus (i.e., electromagnetic interference, EMI, from the computing hardware). However, in the SRI/Langley Porter study, EMI had been eliminated, thus, it remains possible that the CNS changes resulted from an anomalous form of information transfer.

I INTRODUCTION

1. Physiological Correlates to Psychoenergetic Functioning: A Brief History

Evidence from several laboratories has indicated the possible existence of an as-yet-unidentified channel wherein information is coupled from remote electromagnetic stimuli to the human nervous system. Usually, the coupling has been indicated by physiological responses, even though there was no evidence of cognitive awareness of these stimuli. Physiological measures have included a plethysmographic response[1*] and electroencephalogram (EEG) activity.[2,3] Kamiya, Lindsley, Pribram, Silverman, Walter, and others have suggested that the whole range of EEG activity, including evoked potentials, spontaneous EEG, and the contingent negative variation (CNV) might be sensitive indicators of responses to any remote stimuli.[4]

In 1974, SRI International conducted a pilot study that investigated a single remote viewer's central nervous system (CNS) response to a remote light stimulus.[5] In this experiment, the viewer was asked to focus attention on a remote flashing (16-hertz [Hz]) light. Control periods (no light flashing) were randomly mixed with effort periods (light flashing). The viewer was further asked to register when he[†] perceived the flashing light by pressing a button.

During this pilot experiment, the viewer showed a significant[‡] decrease in alpha production when the remote light was flashing, compared with when the light was off. His button presses were random, however, indicating he was not cognitively aware of the flashing light. Two replications of this experiment were conducted with the same viewer at Langley Porter Neuropsychiatric Institute in San Francisco by Drs. David Galin and Robert Ornstein.[6] In the first of two experiments, the viewer continued to show a significant decrease of occipital alpha production only under the remote flashing light condition. In a second experiment conducted 3 months later, however, the viewer demonstrated a significant increase of occipital alpha production.

Although we found that significant correlations appear to exist between the times of light flashes and CNS activity, we considered this result to be only suggestive, with a definitive conclusion requiring further experimentation.

With the advent of more sensitive CNS monitoring equipment, known as magnetoencephalography (MEG), and with an additional 15 years of remote viewing experience, SRI conducted an experiment to explore possible correlations between CNS activity and remote stimuli. This experiment is the subject of this report.

2. Technological Background

Magnetoencephalography is a noninvasive technique used to measure, in three-dimensional space, magnetic fields produced by neuronal electric currents in the cortex of the brain. A magnetoencephalography device (MEG) can determine the spatial distributions of specific groups of neurons participating in a given activity and their patterns of activity over time. This technology has been used in research ranging from evaluating how normal brains process information to diagnosing clinical conditions such as epilepsy and dementias.[7]

Neurons that participate in a given functional activity communicate between themselves and ultimately other parts of the body by a complex combination of electrical signals and chemical interactions. It is beyond the scope of this report to describe the cellular physiology involved, but is sufficient to say that this activity produces magnetic fields (predominantly dipole) that can be sensed externally.

The sensing device of a MEG is a cryogenic superconducting quantum interference device (SQUID) coupled with a gradiometer. SQUIDs currently being used are cooled by liquid helium. At a few degrees above absolute zero, an electrical current can flow through a superconductor with no applied voltage. The material of the SQUID consists of superconducting loops with two sections of thin insulating material connecting them (Josephson Junctions). This configuration is referred to as a DC SQUID. Some electrons can tunnel through this insulation. The

* References are at the end of this report.

† To keep the identity of the viewers confidential, we use the pronouns *he* and *his* throughout this report, regardless of the viewer's gender.

‡ Throughout this report, the word "significant" conforms to the standard definition; $p \leq 0.05$.

presence of a weak magnetic field produces a phase difference for the wave function of the magnetic field [and] produces a phase difference for the wave function of the electrons across this barrier. The resulting interference pattern produced by the two different wave functions on each side of the barrier can be used to indicate the strength of these extremely weak magnetic fields.

The neuronal magnetic fields from the human brain are only about 10^{-13} tesla, while the earth's magnetic field is 10^{-4} tesla and normal urban noise is about 10^{-7} tesla. Care must be taken, therefore, to assure that the signal-to-noise ratio is favorable. This has been taken into consideration by the manufacturer of MEG equipment (BTi of San Diego, California), who has designed highly shielded sensors that use a second-order coupled gradiometer to reduce the environmental noise by about 10^6. The use of an aluminum and μ-metal magnetically shielded room can further reduce the noise by a factor of 10^3. If used together, these two precautionary measures can reduce the ambient noise by a factor of about 10^9—equivalent to the internal SQUID noise.

Because a MEG responds best to neuronal currents that are parallel to the skull (i.e., currents producing magnetic fields oriented tangentially to the skull), neuronal currents perpendicular to the skull may be missed. In reality, however, few neuronal electrical currents are exactly perpendicular to the skull, so some tangential component is almost always available to the SQUID.

Searching for a closely packed group of neurons can be a slow and tedious process. Due to technological restraints, a maximum of seven sensors can be used simultaneously to gather MEG measurements. Sensors on a seven-channel MEG are located on a 2-cm equilateral triangular grid forming the center and vertices of a regular hexagon. A subject wears a spandex cap with grid marks lined up with his nasion, inion, and earlobes to serve as a head-centered coordinate system. To identify the location of a neuronal-equivalent current dipole, many measurements have to be taken. Isocontour maps of field strength are used to represent the amplitude and polarity distribution of the magnetic fields. A least-squares procedure is applied to the observed fields to estimate the location of neuronal sources and orientation of the equivalent current dipole.[8] The estimated location of the neuronal source can then be identified anatomically with a magnetic resonance image scan of the head. Developments in technology may soon allow for enough channels to cover the whole head at once, thereby reducing data collection time and increasing precision.

MEG technology is based on a cryogenic SQUID operating in liquid helium. Because the Dewar flask cannot exceed a 45-degree angle, subjects must lie prone beneath the apparatus. MEG sensors are not attached to the head, but are lowered into position over the skull; the subject cannot move his head during monitoring without disturbing the measurement. For these two reasons, MEG equipment is not suited for long-term monitoring of a subject. These problems may be solved in the near future as new technology, such as high-temperature SQUIDs, develops.

A response from the MEG is a complex waveform consisting of a series of negative and positive peaks or components. Specific components of this waveform can be correlated with perceptual and cognitive processes. The most commonly observed response to a visual or auditory stimulus, for example, is a large component occurring approximately 100 ms after the onset of the stimulus. One hundred milliseconds appears to be the average latency period between stimulus and the first correlated neuronal activation in the brain.[8]

The earlier EEG technology measures electric potential, or event-related potentials (ERPs) produced by the electrical activity of the brain. A MEG measures the magnetic fields, or event-related fields (ERFs) produced by the electrical activity of specific groups of active neurons in the cortex. An EEG and a MEG, therefore, reveal different aspects of the electrical activity of the brain and are often used as complementary technologies. In some areas, however, the MEG technique has definite advantages over the EEG:

(1) ERPs taken from the scalp provide little information regarding the precise three-dimensional distribution of the neuronal sites producing the electrical activity. Brain tissues of unknown electrical conductivity and thickness, individual variations in skull thickness and geometry, and proximity to openings in the skull all make obtaining such detailed information difficult. The same is not true when using a MEG. Neuronal magnetic fields can travel through brain tissues without being significantly altered; this property, coupled with the dipole model, results in high spatial resolution of the neuronal activity.

(2) EEG procedures are occasionally costly and can be invasive: EEG electrodes must be attached directly to the skull or to the brain of the subject, whereas MEG sensors are extracranial and are simply lowered into position against the skull.

(3) There is much controversy over the appropriate reference electrode in EEG work (a reference electrode is required with electric potential measurements, because only differences in electric potential are measured). There is no such problem with a MEG, because the measurement of magnetic fields is absolute.

II METHODS OF APPROACH

Our goal was to conduct a conceptual replication of the earlier SRI/Langley Porter experiments. Our basic hypothesis is that a viewer's CNS would respond to a remote light stimulus.

1. General Description

Using a seven-sensor MEG in a shielded room, we investigated the occipital-cortex neuronal magnetic activity that might occur in response to a remote "visual" stimulus.

The following definitions may be helpful:

- Viewer—An individual who attempts extrasensorimotor communication with the environment (e.g., the perception of remote stimuli).
- Direct Stimuli (DS)—Visual stimuli occurring within the normal visual sensory channels.
- Sender—An individual who, while receiving direct stimuli, acts as a putative transmitter to a remote individual (i.e., viewer) who is attempting to receive the same information via extrasensorimotor communication.
- Remote Stimuli (RS)—Visual stimuli occurring outside the normal range of known sensory channels.
- Pseudo Stimuli (PS)—A time marker in the data stream with no associated stimuli.

In this report, a direct stimulus to the sender is also considered as a remote stimulus to the viewer.

2. Protocol

2.1 General Considerations

To begin a session, a sender is isolated in a room while a viewer is monitored by a MEG in a shielded room about 40 m away. Only the sender is presented with a number of direct visual stimuli at random intervals within a 120-second period, the length of one run. One session usually consists of 10 runs.

2.1.1 Viewers

Eight viewers were selected for this experiment. Four were known to be good remote viewers, and four were staff members with unknown viewing ability. Each viewer contributed a minimum of one and a maximum of three independent sessions.

2.1.2 Senders

The senders in all sessions were either various staff members who were well known to the viewers or they were spouses.

2.1.3 Dependent Variable

The dependent variable is the root-mean-square (RMS) phase shift of the primary alpha activity as a result averaged over all RS.

2.2 Specific Protocol Details

2.2.1 Stimuli

Remote stimuli consisted of a standard video encoded blank screen with a 5-cm square, linear, vertical, sinusoidal grating lasting about 100 ms. These stimuli (DS to the sender) subtended 2 degrees in the lower left visual field of the sender. This was maintained by asking the sender to focus his visual attention on a permanent mark on the monitor. During the experiments described in this report, no attempt was made to monitor the sender in any way. Pseudo stimuli consisted of the blank screen without the superimposed grating, and were included as a putative within-run control.

2.2.2 Run Timing

Figure 1 shows a schematic timing diagram for one run. No two stimuli of any type were allowed to occur within a 3-second period of each other. A stimulus may occur, however, any time within a

4.5-second window thereafter. The sender was presented with a minimum of 9 and a maximum of 15 DS occurring at random intervals within a 120-second period. In all but the first session, a random number of pseudo stimuli (i.e., random time markers with no concomitant stimuli—PS) were added as a within-run control. A viewer was never presented with direct stimuli except in locating the maximal response to the visual areas (see Section II.2.2.4).

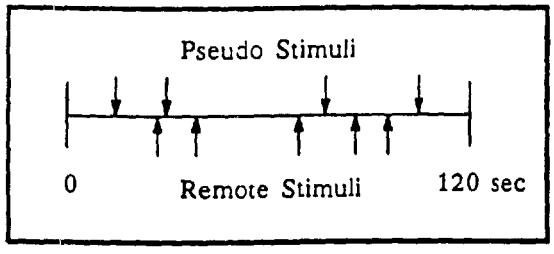

Figure 1 Schematic Timing Protocol—Single Run

2.2.3 Instructions to Viewers

In all sessions, the viewers were completely informed about the details of the experiments. Prior to their placement on the MEG table, they were shown the location of the RS display monitor, and were instructed to place their attention upon it or the sender during the session.

For some sessions, the viewer was instructed to press a fiber-optic-coupled button when he felt that he perceived stimuli. Each button press was marked in the data record. Button pressing was retained in this protocol as part of the conceptual replication.

2.2.4 Sensor-array Placement and Calibration

We selected the location for the sensor array by optimizing the viewer's response to direct visual stimuli. Inherent in this choice is an assumption that may not be valid: namely, that neurons participating in a reaction to RS are the same as those that respond to DS. The sensor locations were then marked on an acetate transparency to allow for accurate repositioning of the sensors in later sessions. One such placement (right occipital—minus centimeters from the inion indicate the right hemisphere) is shown for viewer 002 in Figure 2. It should be noted that MEG sensor placements do not necessarily correspond to conventional EEG electrode placement.

For a calibration, the viewer was fitted with a spandex cap with grid marks aligned with his inion, nasion, and earlobes (i.e, head-centered coordinate system). The viewer was then placed as comfortably as possible on an observation table beneath the MEG. He must lie face down and look though a hole in the table to view the DS via a system of mirrors. These stimuli were displayed by a projector located outside the entrance to the shielded room. The sensors of the MEG were lowered from above to touch his head over the right occipital lobe. In this configuration, the sensor array was moved at the end of 30 DS to a position that optimized his response to the DS. Once found, the array position was marked on the cap for subsequent repositioning.

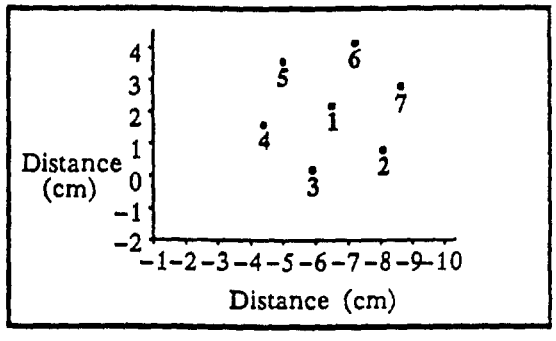

Figure 2 Sensor Position Relative to the Inion (0,0) for Viewer 002

2.2.5 Sequence of Events for a Session

The following is the schedule of events for a session:

- Collect approximately 10 minutes of background data with no viewer or sender present and the MEG in full operation.
- Isolate the sender with the stimulus display device.
- With the viewer on the table, position the sensor array at the calibration point.
- At time = 0, start the monitoring of data with computer-generated trigger. Data are collected the entire 120 seconds at a rate of 200 samples per second.
- At time < 120 seconds, present 9 to 15 remote and 9 to 15 PS to the sender.
- At time > 120 seconds, allow the viewer to relax for about 2 to 5 minutes without leaving the table. This break generally consists of the sender entering the shielded room to engage the viewer in conversation.
- Collect nine additional runs with the same procedure while the viewer remains positioned on the table under the MEG.

3. Data Analyses

If our initial assumption about sensor positioning is true, and if the earlier results are replicated, we expect to see a change in alpha production as a result of the RS. We might also expect an evoked response similar to visual ERFs. Figure 3 is an idealized illustration of these expected results in the time-series data. Times less than zero are prestimulus; times greater than zero are poststimulus. The stimulus lasts 100 ms.

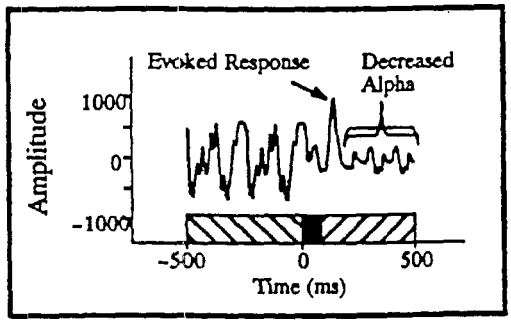

Figure 3 Idealized Results for a Single Stimulus

For each session, the following was computed for each RS and PS, respectively:

(1) Five hundred ms of pre- and post-stimulus time-series data were separately detrended and filtered (40 Hz lowpass).

(2) The power spectrum was computed for each 500-ms pre- and post-stimulus period.

(3) The relative phase change of the dominant alpha frequency from pre- to post-stimulus period was computed as the arctangent of the ratio of the imaginary and real component of the transfer function. The transfer function is defined as the ratio of the FFT of the post-stimulus period divided by the FFT of the pre-stimulus period.

(4) One thousand ms of time-series data (i.e., 500 ms pre- and post-stimulus) was separately detrended and filtered (40 Hz lowpass).

In addition, the following averages were computed across all RS and PS, respectively:

(5) The average power pre- and post-stimulus.

(6) The root-mean-square (RMS) average phase shift.

(7) The 1000-ms time average of the pre- and post-stimulus periods taken as a single record.

(8) The "power spectra" of the pre- and post-stimulus time averages were computed. (We recognize that a power spectrum of a time average is not an accurate representation of the average power spectrum, however it is an indicator of phase shift.)

4. Monte Carlo Calculations

The analysis of CNS activity has always been problematic, because alpha bursts lasting from 0.1 to a few seconds occur at random intervals. From a statistical point of view, the data fail to satisfy at least two underlying assumptions of the usual statistical methods (e.g., ANOVA and MANOVA). Most standard statistical tests assume that all samples of the data are independent. MANOVA can be configured to remove this particular assumption, nonetheless, it and the other tests assume that the process under study is stationary; that is, whatever the statistical properties are, they remain constant over time. In other words, the measured properties should not depend upon when the activity is sampled. CNS time series data do not satisfy either of these assumptions.

To avoid these difficulties, and to obtain probability estimates of the observed RMS phase shifts, we adopted a simple Monte Carlo approach. In the usual statistical analysis, the phase shift is compared to an ideal distribution, or its likelihood of occurrence is computed using some nonparametric technique. Both techniques attempt to determine the degree to which the observed phase shift is exceptional, given the universal set of all possible data. The Monte Carlo method that we used, however, can only determine the degree to which the observed phase shift is exceptional, given the available data sample. Thus, a new Monte Carlo estimate must be computed for each individual data set.

The general Monte Carlo procedure is as follows:

(1) Using the same timing algorithm to create the original RS, generate N sets of M stimuli, where M is the number of original RS.

(2) For each pass ($1...N$), compute the RMS phase shift averaged over M remote stimuli.

(3) Sort the resulting N values to form the RMS phase shift distribution in the given data sample.

(4) Compute the probability that the observed value would be as large (or larger), given a repeated random sample of the data. Note that

this p–value is *not* the probability that the measure is as large, given a different data sample.

We have used this technique to compute p–values for the RMS phase shifts throughout this report.

III RESULTS

Eight viewers (002, 007, 009, 372, 374, 389, 454, and 531) from SRI International participated in the effort. Viewers 002, 009, 372, and 389 were experienced, with strong track records. Viewers 007, 374, and 531, had not previously participated in remote viewing experiments. Viewer 454 had participated in novice remote viewing training and has produced significant evidence of remote viewing ability.

1. Calculations

To illustrate the reduction of the raw data, we use the 25 September 1988 session from viewer 002.

Figure 4 shows the time average over all RS of the amplitude (femto Tesla) of the magnetic CNS activity of viewer 002's response to RS. The data from all seven sensors are displayed in a pattern that is similar to the physical sensor array. Each sensor is labeled in a highlighted box. The number of stimuli comprising the average (118) is shown in the key. The onset of the 100–ms stimulus is represented at *time = 0*, so negative time represents the pre-stimulus period and positive time represents the post-stimulus period. The total time period shown is 1 second. Because the stimuli are at random times relative to any uncorrelated CNS activity, averaging has reduced random single-stimulus amplitudes by $\sqrt{n}$ where n is the number of stimuli. Sensor 7 shows a clear change from a slow, regular alpha rhythm during the pre-stimulus period, to one of higher frequency, post-stimulus.

Figure 5 shows this change of alpha in the frequency domain. For each sensor, the power spectrum of its corresponding time series is displayed from 0 to 40 Hz. The power spectra are shown independently for the pre- and post-stimulus periods (separated by a dashed vertical line). Sensor 7 shows a strong 10–Hz peak pre-stimulus that vanishes post-stimulus Similar alpha reductions can be seen in all of the other six sensors.

The power spectrum of a time series average is *not* an indicator of the average power spectrum of the CNS activity, because time averages are phase sensitive and power spectra are not. Figure 6 illustrates this by showing the average power spectra (i.e., calculated on a stimulus–by–stimulus basis and then averaged) for the pre- and post-stimulus periods. There was little change of CNS power across the stimulus boundary throughout the frequency range.

Because a time average is sensitive to relative phase and a power spectrum is not, these data suggest that a relative phase shift occurs between pre- and post-stimulus periods. Figure 7 shows this relative RMS phase shift computed from 0 to 40 Hz for all sensors. As was the case for the time-series data, the RMS average was computed over $n = 118$ RS. In accordance with the protocol (Section II.3), the dependent variable was the RMS phase only at the dominant α–frequency.

At this point we are unable to determine if the variations seen in Figures 4 through 7 are meaningful. Toward that end, the identical quantities for the PS are shown in Figures 8 through 11. The "power" of the time averages for the remote stimuli differ markedly from those of the PS spectra (Figures 5 and 9).

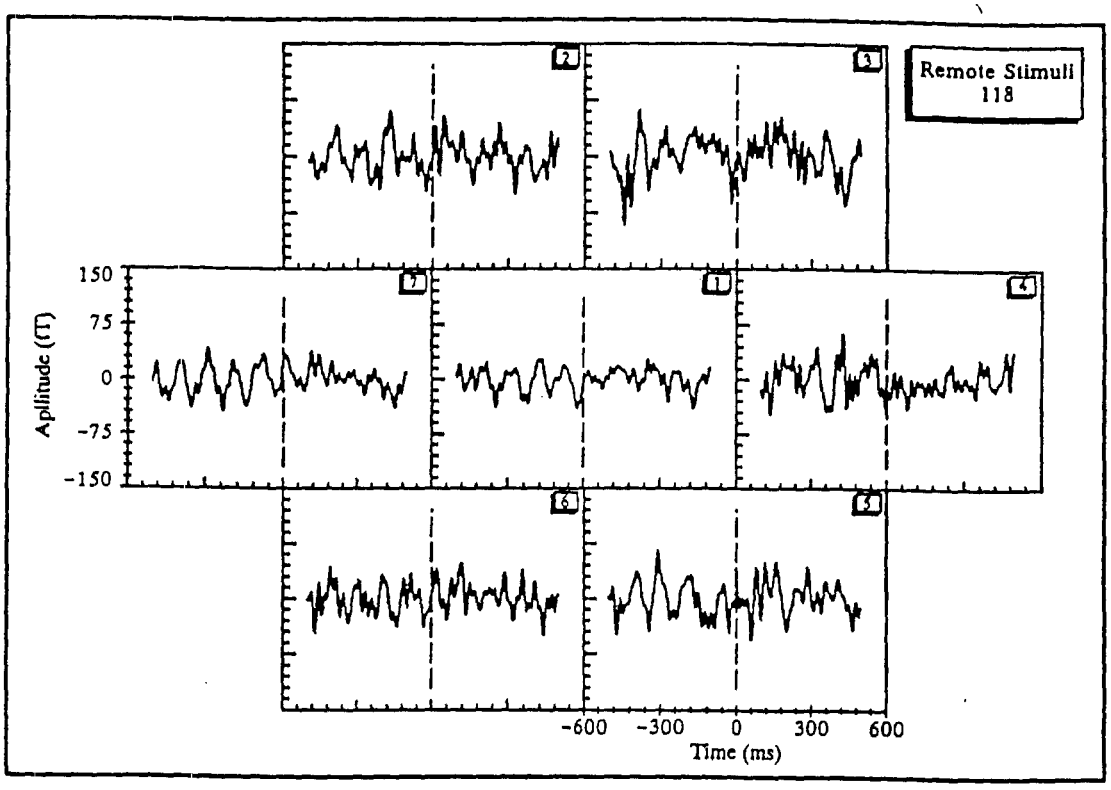

Figure 4 Viewer 2: Date 8/25/88: Session 1: Time Average

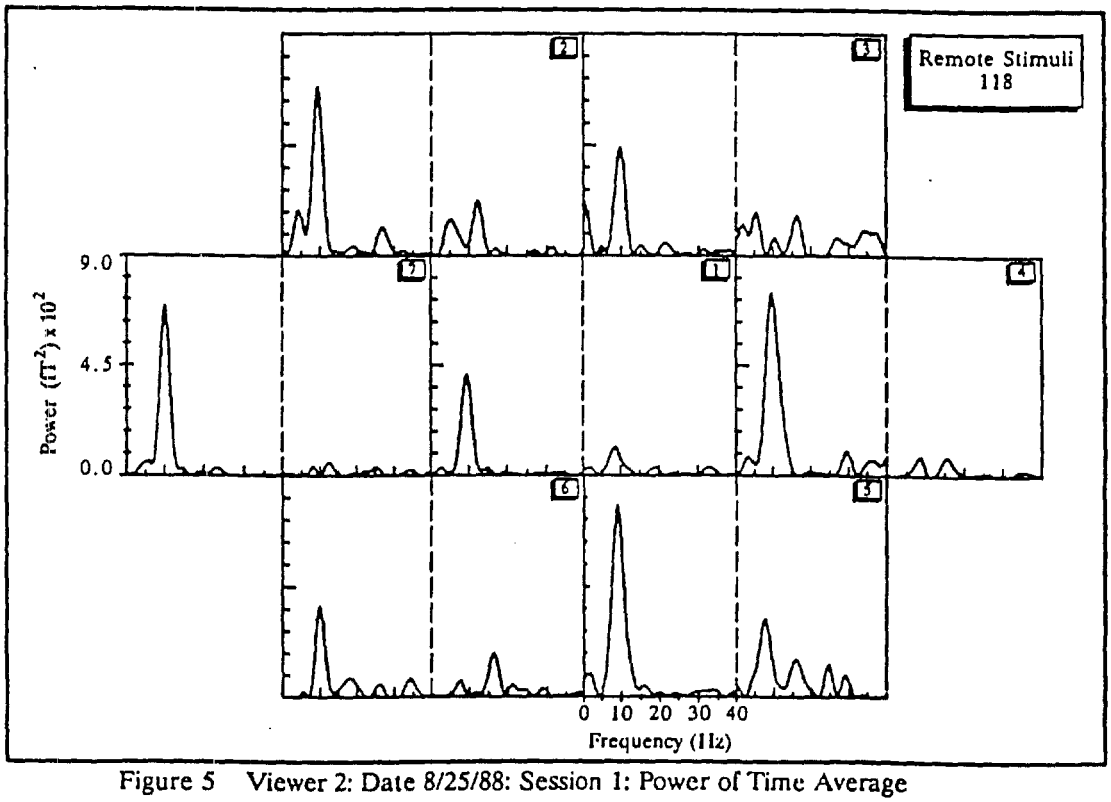

Figure 5 Viewer 2: Date 8/25/88: Session 1: Power of Time Average

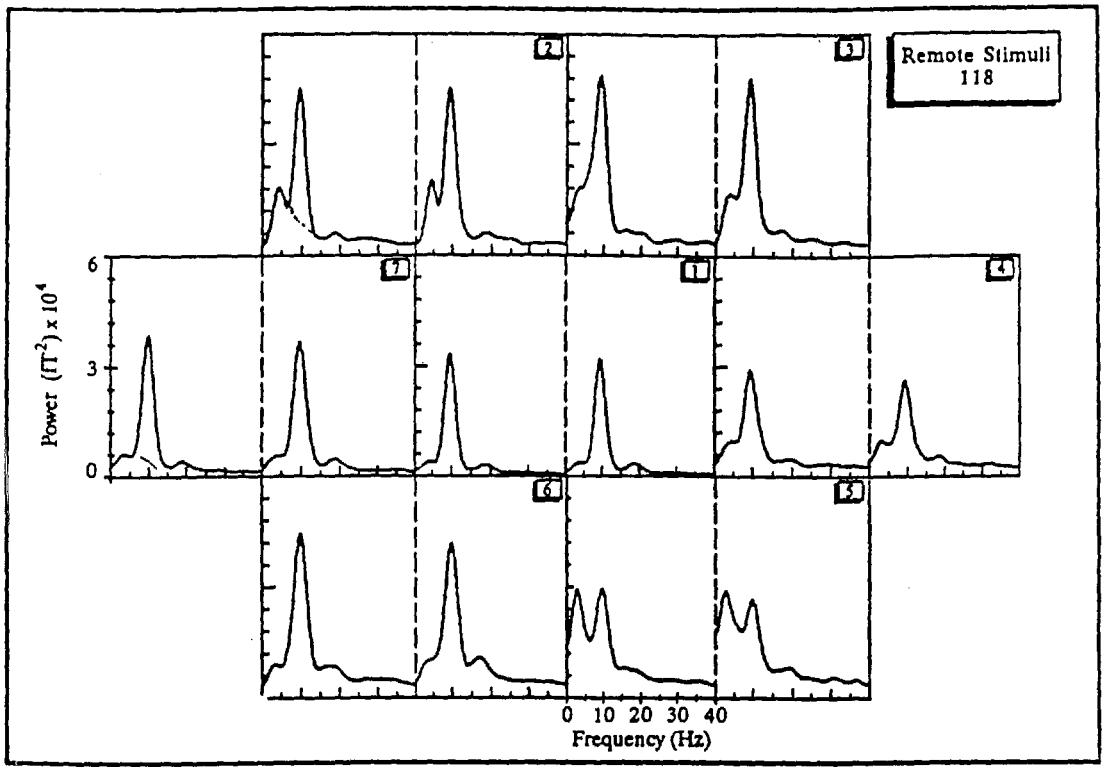

Figure 6 Viewer 2: Date 8/25/88: Session 1: Average Power

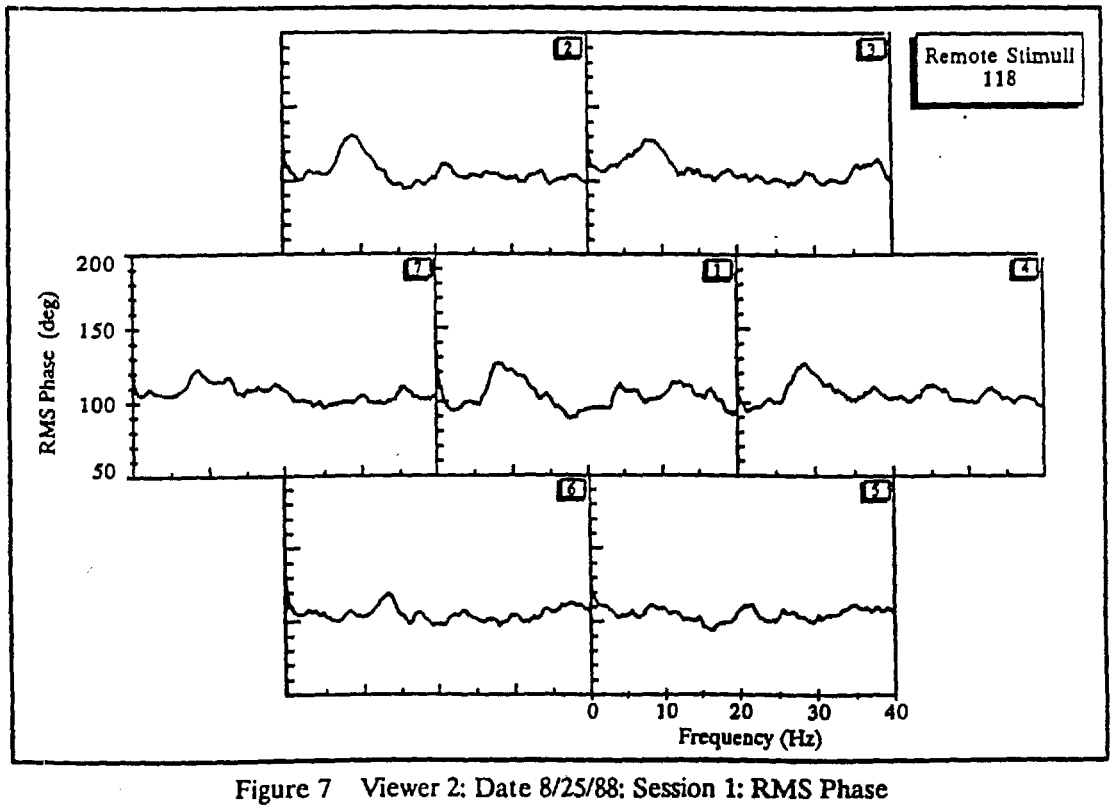

Figure 7 Viewer 2: Date 8/25/88: Session 1: RMS Phase

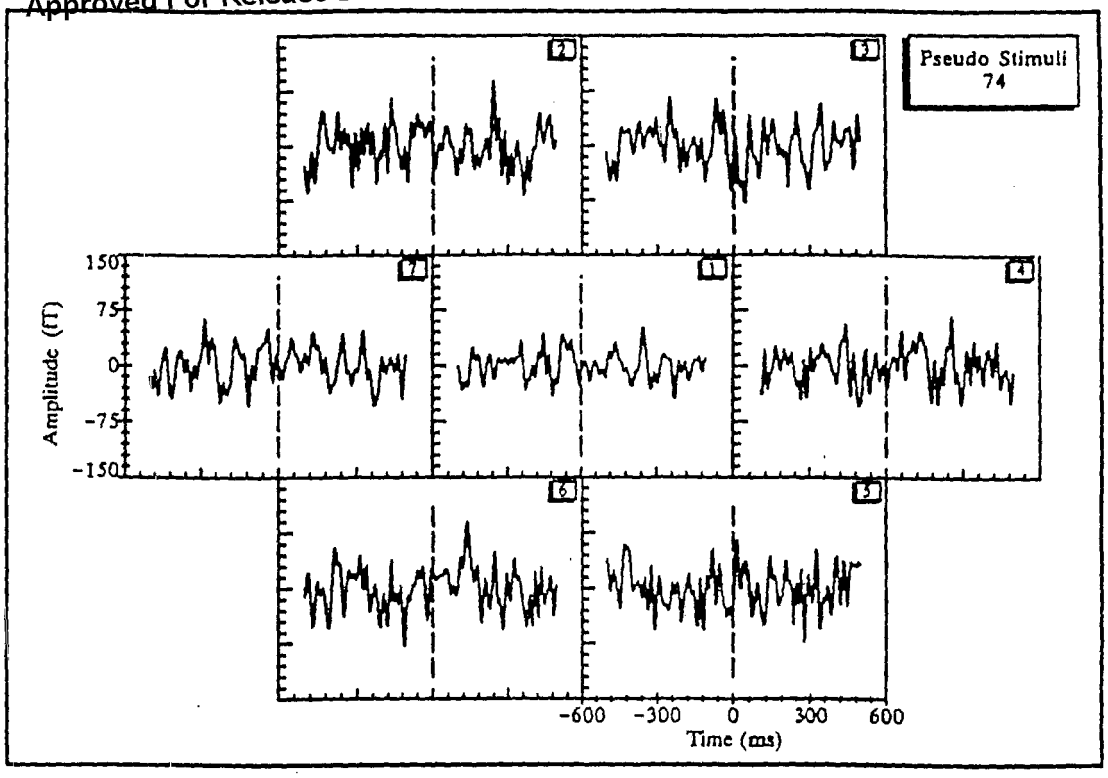

Figure 8 Viewer 2: Date 8/25/88: Session 1: Time Average

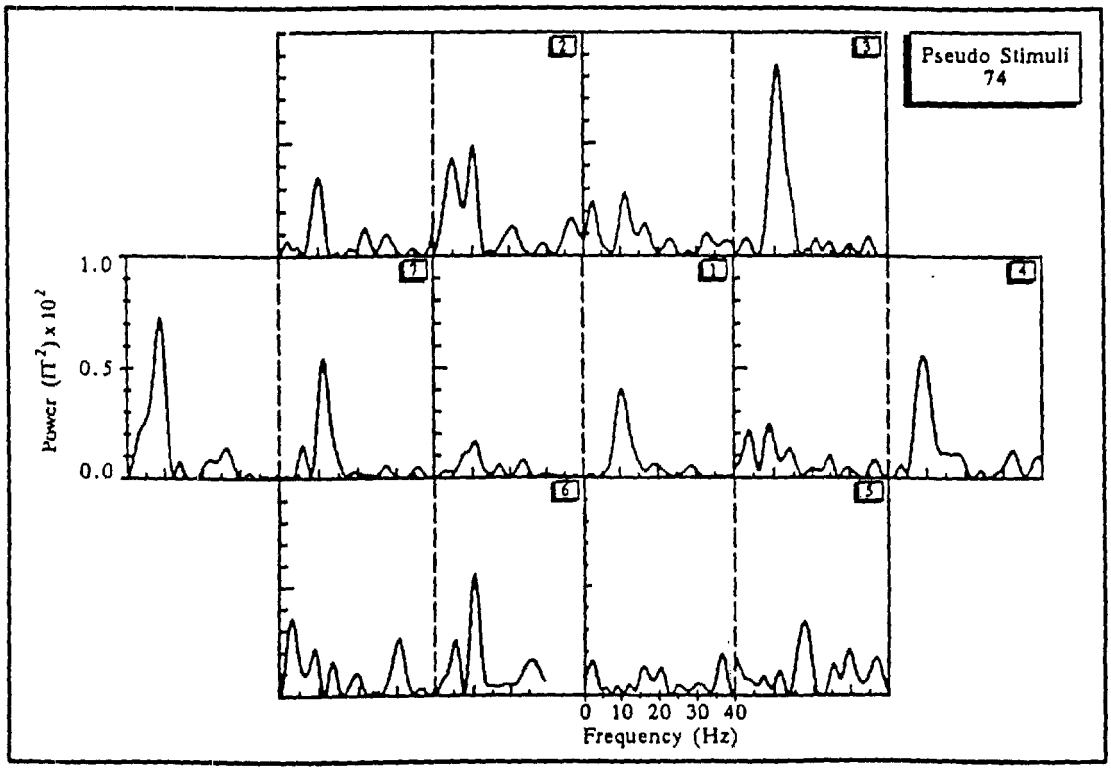

Figure 9 Viewer 2: Date 8/25/88: Session 1: Power of Time Average

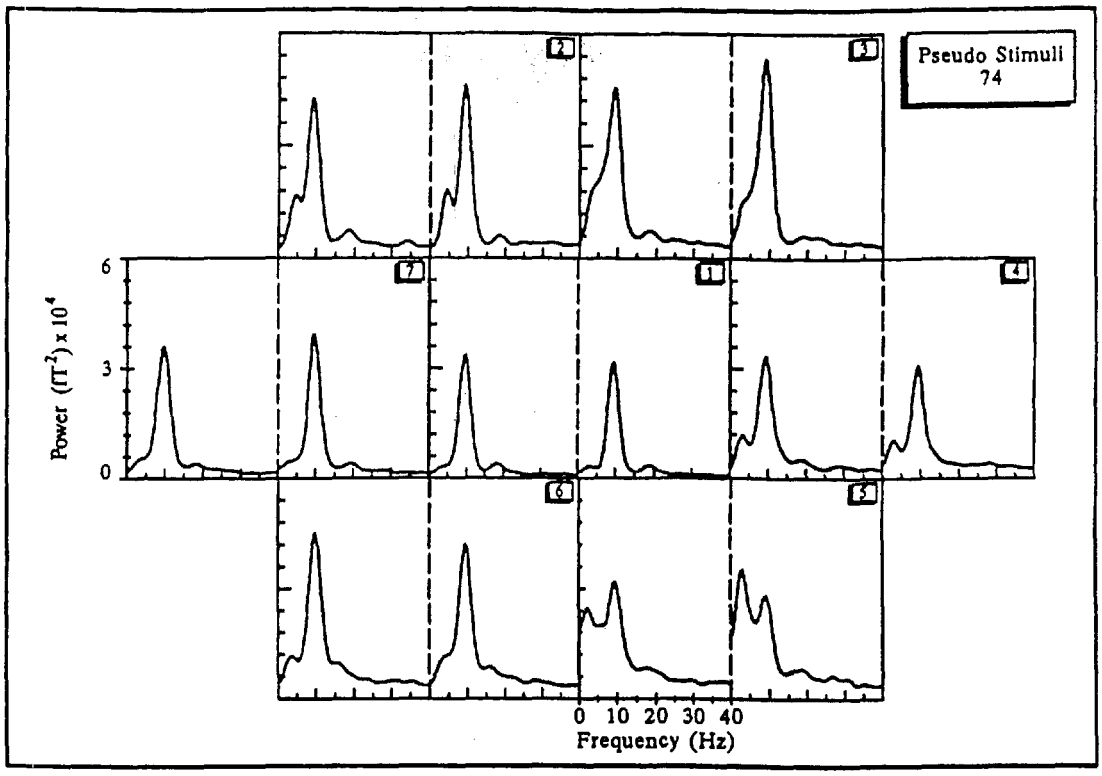

Figure 10 Viewer 2: Date 8/25/88: Session 1: Average Power

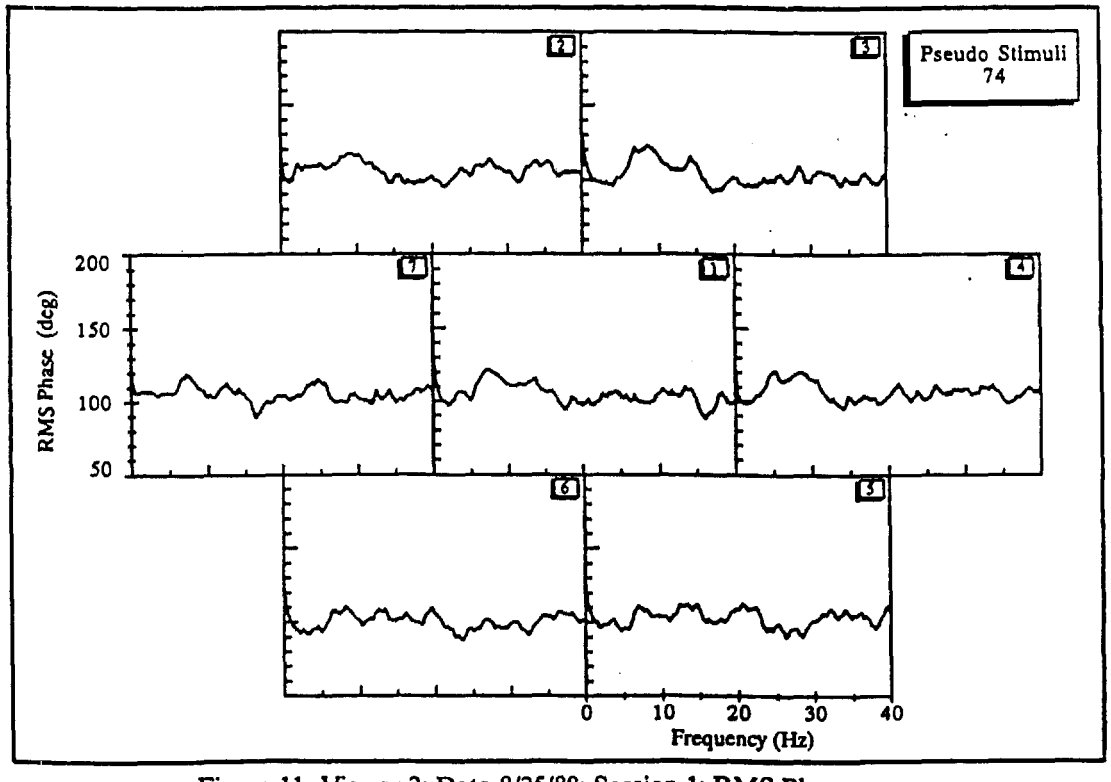

Figure 11 Viewer 2: Date 8/25/88: Session 1: RMS Phase

2. Monte Carlo Estimates of Significance

To determine if the changes that are seen qualitatively are exceptional, we analyzed the data by the Monte Carlo procedure outlined in Section II.4. We simulated the RS by generating 500 sets of Monte Carlo stimuli using the same random timing algorithm and number as in the original data. For each set, the RMS phase was calculated as described in Section II.3. The resulting 500 Monte Carlo RMS phases were sorted as a descending array, and the fraction of phases equal to or larger than the observed RS value was represented as a p-value. (The p-value is bounded on the low end by 1/500.) Figure 12 shows a histogram of one such Monte Carlo run, again using the data from viewer 002 as an example. The values of the RMS phase for the remote and pseudo stimuli are marked by vertical lines (see the key in Figure 12).

In accordance with the earlier study[6] in which we observed changes in alpha power, we established a single criterion for the selection of a sensor for analysis: the pre-stimulus average alpha power above background is larger than it is in any other sensor. Table 1 shows the viewer identification, date, sensor chosen for analysis, and the p-value (as defined above) for the RMS phase shift for the remote and pseudo stimuli, respectively.

The p-values shown in Table 1 are all single tailed (i.e., the area in the upper tail). Because the distribution of means is approximately normal, we have converted the empirical p-values to their respective two-tailed z-scores. If the p-value was less than 0.5, the z-score shown in Table 1 was computed from the inverse normal distribution assuming a p-value twice the one shown. If the p-value was more than 0.5, we subtracted it from 1.0, doubled the result, and computed the z-score as above. To test the null hypothesis that the combined RS phase shifts are characteristic of the data, we computed a standard Stouffer's Z (Z_s) for the 11 sessions shown in Table 1. There is statistical evidence that the data within $\pm$ 0.5 seconds of the RS are *not* characteristic of the data at large ($Z_s = 1.99, p \leq 0.024$, *effect size* = 0.599). Similarly, the combined statistic for the PS indicates that these data are also *not* characteristic ($Z_s = 2.92, p \leq 0.002$, *effect size* = 0.924). Therefore, there appears to be some statistical anomaly associated with the RMS phase shifts for both stimuli types.

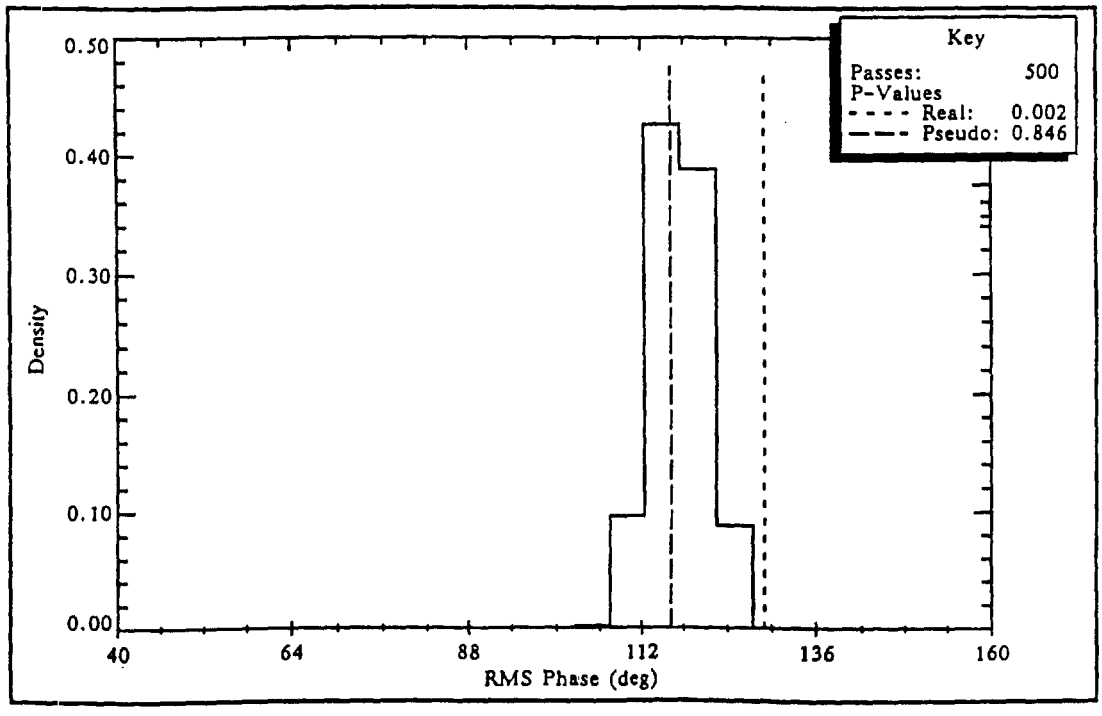

Figure 12 Viewer 2: Date 8/25/88: Session 1: RMS Phase: Sensor: 2: RS = 118

Table 1

Results of Monte Carlo Calculation for RMS Phase

I.D.	Date	Sensor	P-Value (1-tail)		Z-Score (2-tail)	
			Remote	Pseudo	Remote	Pseudo
009	06/24/88	6	0.650	-	-0.524	-
002	08/25/88	2	0.002	0.848	2.653	0.513
	08/26/88	6	0.904	0.966	.0.871	1.491
372	10/19/88	7	0.094	0.168	0.885	0.423
374	03/29/89	6	0.154	0.810	0.501	0.305
007	03/29/89	7	0.970	0.180	1.555	0.358
389	05/23/89	4	0.288	0.040	-0.191	1.405
	05/24/89	5	0.260	0.016	-0.050	1.852
	05/25/89	4	0.120	0.922	0.706	1.011
531	05/24/89	4	0.814	0.134	0.274	0.619
454	05/25/89	4	0.732	0.052	-0.090	1.259

3. Results: Button Presses

In the early SRI study[6], significant changes in alpha production were observed in response to an RS. The statistical evidence, however, did not indicate that the viewer was able to recognize an RS cognitively (i.e., the viewer's button presses relative to the RS did not exceed mean chance expectation).

In the current experiment, viewers 002, 009, and 372 were asked to press a button whenever they "perceived" an RS. The total number of stimuli during a session of 10 runs was not known in advance because of the randomization procedure. The null hypothesis is that the probability of a time interval having a stimulus is the same for those intervals with a button press as for those without a button press. In other words, the presence or absence of a stimulus is independent of the presence or absence of a button press. We tested this null hypothesis to determine if a viewer is cognitively aware of the RS.

In Table 2, the fractional hitting rate is $p_1 = A/(A+B)$, and the fractional missing rate is $p_2 = C/(C+D)$. The total number of 1-second intervals is $N = (A+B+C+D)$, and the total stimulus rate is $p_0 = (A+C)/N$.

Table 2

Data Schema for Interval Conditions

		Stimulus	
		Yes	No
Response	Yes	A	B
	No	C	D

Then, under the null hypothesis, the following statistic is approximately normally distributed with a mean of 0 and a variance of 1:

$$z = \frac{(p_1 - p_2)}{\sqrt{p_0(1-p_0)\left(\frac{1}{(A+B)} + \frac{1}{(C+D)}\right)}}.$$

Table 3 shows N, p_0, p_1, p_2, z, p-value, and the effect size, r, for the three sessions for which button-press data were collected. As in the earlier SRI study, there is no indication that the viewers were cognitively aware of the RS.

Table 3

Button Pressing Results

Viewer	N	p_0	p_1	p_2	z	p	r
002	1210	0.167	0.198	0.164	0.951	0.163	0.027
009	1280	0.091	0.068	0.094	-0.978	0.836	-0.027
372	1089	0.157	0.119	0.160	-0.996	0.840	-0.030

IV DISCUSSION AND CONCLUSIONS

We have found statistical evidence that the relative phase shift from –0.5 to 0.5 seconds of an RS are *not* characteristic of the data at large (Z_s = *1.99, p ≤ 0.024, effect size = 0.599*). The combined statistic for the PS indicates that the relative phase shift from –0.5 to 0.5 seconds of a PS are also *not* characteristic of the data at large (Z_s = *2.92, p ≤ 0.002, effect size = 0.924*). Averaged across all viewers, the magnitude of the results, as indicated by their effect sizes of 0.599 and 0.924, respectively, is considered robust by accepted behavioral criteria defined by Cohen.[9*]

1. Root-Mean-Square Phase

Searching for a change of phase as a result of an RS is a natural extension of results quoted in the literature. For example, Rebert and Turner[5] report an example of photic driving (i.e., an extreme example of phase locking) at 16 Hz. In their work, a subject was exposed to a 16-Hz visual DS randomly balanced with no stimulus during 4-second epochs. The average power spectra showed approximately 10-Hz alpha activity during the no-light epochs, and a strong 16-Hz and no 10-Hz peak during the 16-Hz epochs.

One interpretation of their result is that the alpha rhythm was blocked, and the CNS "locked" on to the flashing stimulus. Eason, Oden, White and White,[10] report a phase-shift phenomenon when a rare stimulus, which is random relative to the internal alpha activity, is presented as a DS:

> *"...when a stimulus flash is presented, the resulting primary evoked response acts as a trigger stimulus which temporarily synchronized a certain percentage of the neural elements normally under the influence of an internal pacemaker. ... Desynchronization of the elements participating in the evoked response would occur as the elements are brought back under the influence of an internal pacemaker or are affected by neurons not involved in the response."*

In other words, the internal alpha is momentarily interrupted by an external stimulus, and, in the absence of continuing external stimuli, returns back to its original frequency, but at a random phase relative to its pre-stimulus state.

To understand what would be expected in our experiment for the distribution of RMS phases during the Monte Carlo simulations, we examine a hypothetical case. Suppose that the viewer's alpha activity was a continuous wave at a single frequency. A phase change is computed between 500 ms before and 500 ms after each Monte Carlo "stimulus." Therefore, regardless of the entry point, the relative phase change would be zero, and the RMS phase over many such "stimuli" would also be zero.

Real alpha activity, however, is not continuous, Rather, it appears in bursts lasting from 100 to 5000 ms. Random Monte Carlo "stimuli" would sometimes occur within such bursts and sometimes near the edges. Thus, we would expect a nonzero RMS phase over many such "stimuli," but the individual relative phases would not be uniformly distributed. Depending upon the viewers' alpha characteristics, the distributions would be enhanced near zero RMS phase.

If we assume that Eason, et al., are correct, and that a phase shift is expected as a result of an RS, then the expected distribution of RMS phases is uniformly distributed on $[-\pi, \pi]$. In this case, the phase change is related to the relative timing between the external stimulus and the internal alpha—a completely random relationship. Thus, the variance of the RMS phases in the experimental condition should be larger than those computed during the Monte Carlo runs. Figure 13 is a schematic representation of these models.

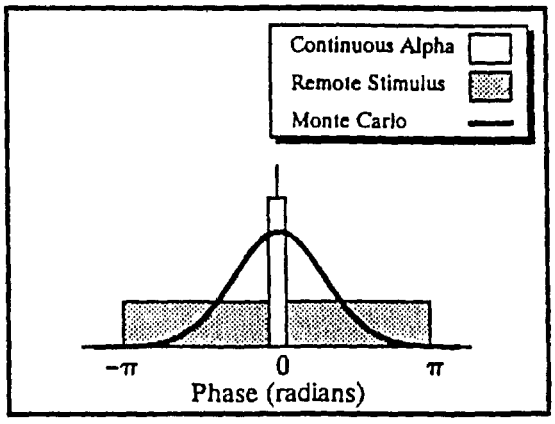

Figure 13 Idealized Distributions for Relative Phase Shifts

* Values of 0.1, 0.3, and 0.5 correspond to small, medium, and large effects, respectively.

As a first step in testing these models, we computed the expected variance for the RMS phase, given that the individual phases are uniformly distributed on $[\pi, \pi]$. Using a Taylor Series expansion for RMS phase, the variance is given by:[11*]

$$\sigma_y^2 = \frac{\frac{3}{45}\pi^2}{n}\left[1 - \frac{1}{30n}\right] \quad (rad^2) \quad , \text{ or}$$

$$\approx \frac{2160}{n} \quad (\text{deg}^2),$$

where n is the number of individual phases.

Table 4 shows the viewer identification, the two-tailed z-score from Table 1, the number of RS, the theoretical variance for the RMS phase, the observed variance from the Monte Carlo runs of 500 passes each, and the X^2 and its associated p-value for a variance-ratio test.

Combining the X^2 across all 11 sessions gives an overall significant result ($X^2 = 5121.5, df = 5489, p \leq 0.0002$). This indicates that the Monte-Carlo–derived variances are significantly smaller than the theoretical variances based on uniformly distributed phases. The two viewers who demonstrated the largest z-scores (002 and 007) also show sharply reduced Monte Carlo variances.

Table 4

Comparison Between Monte Carlo Phases and Theory

I.D.	Z-Score (RS)	Number of RS	Variance of RMS Phase		X^2 df = 499	P-Value
			Theoretical	Observed		
009	-0.524	96	22.50	25.46	564.6	0.978
002	2.653	118	18.31	13.63	371.5	4.9×10^{-6}
	0.871	76	28.42	24.43	428.1	0.010
372	0.885	90	24.00	23.25	483.4	0.316
374	0.501	102	21.18	18.64	439.2	0.025
007	1.555	93	23.23	18.66	400.8	4.6×10^{-4}
389	-0.191	97	22.27	23.35	523.2	0.780
	-0.050	92	23.48	22.29	473/7	0.214
	0.706	98	22.04	20.22	457.8	0.093
531	0.274	101	21.39	21.05	491.1	0.408
454	-0.090	52	41.54	40.48	487.3	0.363

We must conclude that a uniform distribution for the phase is not a good assumption. To determine what the phase distribution was for the RS, we constructed histograms from the raw data.

Figure 14 shows the distribution of phases for the RS and Monte Carlo stimuli for viewer 002. While the RS distribution is enhanced near ± 180 degrees and suppressed near 0 degrees compared to the Monte Carlo distribution, the differences are small ($X^2 = 10.62, df = 8, p \leq 0.224$) and, therefore, the random-phase model does not appear to be a good fit to the data for viewer 002 on his 25 September session.

Figure 15 shows the same distributions for viewer 007. In this case, the RS distribution is nearly uniform on [-180,180] degrees, but it differs only slightly from the Monte Carlo distribution ($X^2 = 9.47, df = 8, p \leq 0.304$).

From the data shown in Table 4, we see that the X^2 indicates significant overall differences between the theoretical and observed phase distributions. However, Figures 14 and 15 show that the differences between RS and Monte Carlo distributions are small. It is most probable, therefore, that the RS coupling to the CNS is weak, in general, and that the position of the sensor array is not necessarily optimized to sense the phase changes.

2. Viewer Dependencies

Viewers 002, 009, and 372 have produced consistent remote viewing results for many years—since 1972 for viewers 002 and 009, and since 1979 for viewer 372. Viewer 389 is a recent addition, and has produced examples of excellent remote viewing in the only experiment in which he has participated; however, he has produced significant results in another laboratory. Whereas viewer 002

* We thank Professor Jessica M. Utts, Statistics Department, University of California, Davis, California, for suggesting this approach.

produced the largest z-score (Z_s = *2.653*), viewer 009 produced the smallest (Z_s = *−0.524*). The combined effect size for the experienced viewers is 0.621, and is 0.559 for the inexperienced viewers. The difference is not significant.

There are two considerations that prevent drawing conclusions about the viewer dependence of the data. The number of independent samples is small, but the most compelling argument against drawing conclusions is that placement of the sensor array is a seriously confounding factor. As stated in Section II.2, we positioned the array in a location that maximized the response to a DS. This may not be the appropriate positioning for everyone. Indeed, it might not be optimal for anyone.

To determine if there were any "obvious" spatial dependencies that might indicate a more optimal array placement, we computed a complete set (all sensors) of Monte Carlo distributions for one session for viewer 002. Figure 16 shows the single-tailed p-values for the RMS phases for the RS and PS. They are displayed in the standard sensor-array configuration. The pattern for the RS suggests that a more optimal positioning of the array would be in the sensor 2–7 direction as indicated by an arrow in Figure 16.

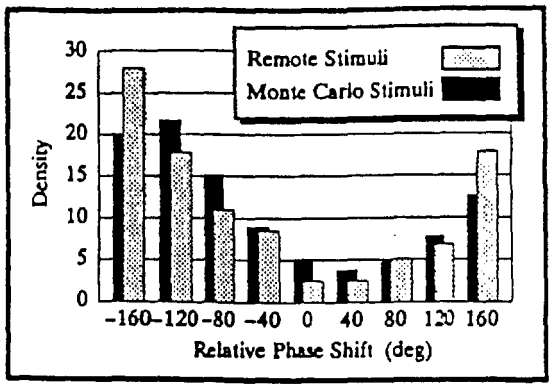

Figure 14 Phase Distributions for Viewer 002: 8/25/88

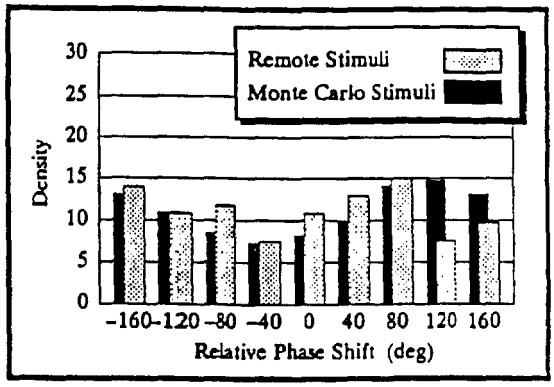

Figure 15 Phase Distributions for Viewer 007: 3/29/89

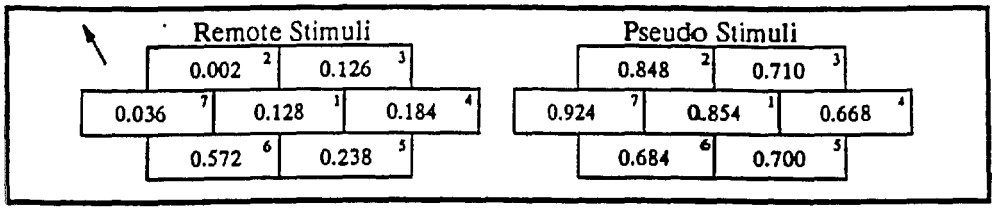

Figure 16 Phase p-values for Viewer 002: 8/25/88

3. Pseudo Stimuli

It was initially thought that the PS would act as a within-run control. The results indicate, however, that there was, on the average, a larger response to the PS than to the RS. While the difference was not significant, it is important to note that both of the responses are considered statistically robust (effect sizes of 0.599 and 0.924 for the RS and PS, respectively). A number of viewers' responses appear to produce phases on opposite sides of the Monte Carlo distributions (e.g., viewers 002 and 007), but there is no overall correlation between the RS and PS p-values.

A brief description of the hardware and software that is responsible for stimulus generation may help in understanding this outcome. The stimuli and their timing are imitated by an HP computer, but are controlled by an IBM PC. Each stimulus type has its own frame buffer within the PC. Our RS consists of a pattern of 1s and 0s that represent a sinusoidal grating in the center of an otherwise blank field. The PS pattern, a blank field that consists of all 0s, resides in a separate buffer. An interface board between the PC and a standard video monitor has its own internal frame buffer, which is automatically and continuously scanned

at 30 Hz to provide a standard interleaved video signal. See Figure 17.

When the HP computer signals the PC to provide the appropriate stimulus, the following sequence of events are followed (see Figure 17):

(1) Phase locked to 60 Hz, the interface frame buffer is loaded with a copy of the appropriate stimulus frame buffer (either RS or PS).

(2) The interface board automatically sends this pattern interleaved at 30-Hz.

(3) After a preset time, approximately 100-ms in our experiment, the PC resets the interface frame buffer to zero (blank screen), and waits until another stimulus signal is received.

At the video monitor, the PS are indistinguishable from the between-stimuli blank screens. At the PC, however, the PS are distinguishable from the blank screen background, because the PC must copy a frame buffer (albeit all 0s) into the output frame buffer.

In our experiment, the RS and PS results were statistically identical, and independently, both were significantly different from the Monte Carlo distributions. This raises the question as to what constitutes the target stimulus. Our result is unexpected given the target was considered to be what was displayed on the remote monitor.

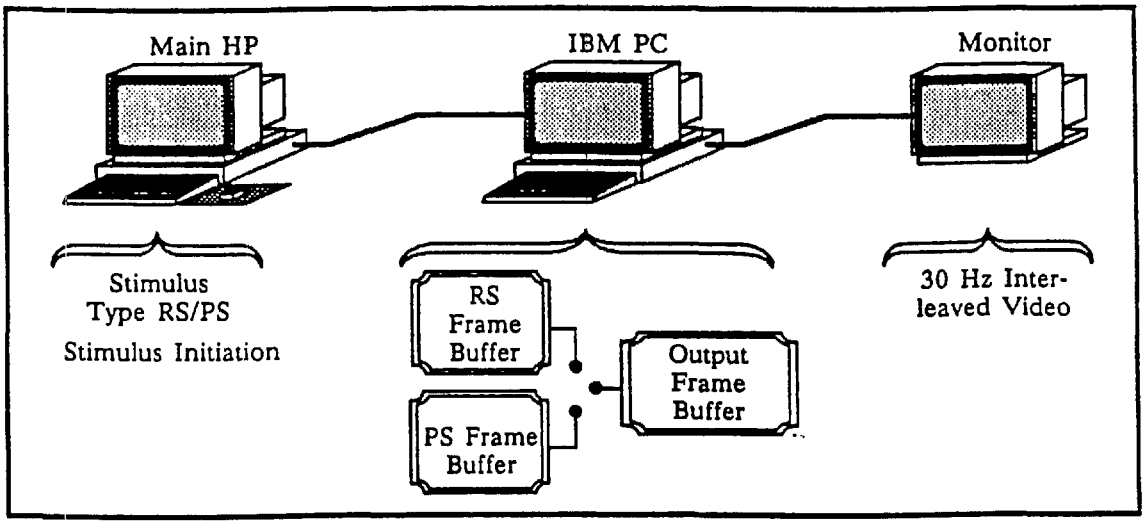

Figure 17 Sequence of Events for Stimuli Generation

It is conceivable that the internal activity of the PC, or its companion computer, was acting as an unintended target. If this were true, then there might be an electromagnetic (EM) coupling between the viewer's CNS and the internal electronic activity of the computers. It is well known that computers radiate EM energies at relatively high frequencies; for frequencies above 100 Hz, the shielded room is transparent. Analysis of the background runs (i.e., data collected in the absence of a sender or viewer) showed no EM coupling into the MEG electronics; therefore, it remains possible that the statistical effects we have seen are due to CNS responses to remote bursts of EM energy.

Let us *assume* that the overall RS and PS effects are meaningful. Since the PSs are *indistinguishable* at the monitor from the between-stimuli background but are *distinguishable* at the IBM PC, then the present experiment demonstrates that the source of stimuli is the IBM PC.

During the SRI/Langley Porter study in 1977, SRI developed an entirely battery operated stimulus generator as a special precaution against the possibility of system artifacts in the form of EM pickup. They reported significant CNS responses to remote stimuli, nonetheless.[6] Therefore, it remains possible that we have observed an anomalous information transfer.

Before further research is conducted, it is important to measure the EM radiation, and to see if it is of sufficient strength to be detected (by the appropriate hardware) in the shielded room.

By adjusting the PC program, the PS internal activity can be eliminated. It would be interesting to see if the similarity between the RS and PS results persists.

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