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PERCEPTUAL AUGMENTATION TECHNIQUES

by

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Client Private

I OBJECTIVE

The purpose of the program is to determine the characteristics of those perceptual modalities through which individuals obtain information about their environment, wherein such information is not presented to any known sense.

The program is divided into two categories of investigation of approximately equal effort, applied research and basic research. The purpose of the applied research effort is to explore experimentally the potential for applications of perceptual abilities of interest, with special attention given to accuracy and reliability. The purpose of the basic research effort is to identify the characteristics of individuals possessing such abilities, and to identify neurophysiological correlates and basic mechanisms involved in such functioning.

II PROGRESS DURING THE REPORTING PERIOD

A. Applied Research

1. Remote Viewing

A number of efforts were begun with respect to obtaining further information concerning remote viewing phenomena. First, an experiment has been designed in consultation with SRI psychologists which will yield precise statistical data as to discrimination ability. Ten sites known to the subject are to be visited in random sequence by a target demarcation team. The subject must then make a choice as to which site is being visited, in addition to providing descriptive material for content analysis.

B. Basic Research

1. Testing Program

During the first month of this program, the Wechsler Adult Intelligence Scale (WAIS) instrument was administered by [redacted] SG1D SG1D [redacted] to three subjects screened in other programs as being gifted in the area of paranormal perception. They are Mr. Patrick H. Price, screened for remote viewing ability, Mrs. Hella Hammid, screened for EEG correlates to remote stimuli, and Mr. Duane Elgin, screened for high scoring response to a random target generator. Further in-depth interviewing of the first two subjects was carried out by SG1D [redacted] A report is in SG1D preparation by [redacted] and will be available to the contract technical representatives when completed.

On the basis of discussion with technical representative, SG1I [redacted] SRI representatives have consulted with a number of Bay Area neurophysiologists concerning administration of the Halstead-Reitan (H-R) Neuropsychology Test Battery. Those contacted include Dr. Karl Pribram of the Stanford Medical School, Dr. Robert Ornstein of the Langley-Porter Neuropsychiatric Clinic, and Dr. Donald Lim of the Veteran's Administration Hospital in Palo Alto. To date satisfactory arrangements for administration of the H-R instrument have not yet been made, as only the latter facility has personnel experienced in its administration, but not ordinarily available for subcontracted consulting. The three individuals named above have, however, agreed to help locate an appropriate individual or facility to carry out such testing so no difficulty is anticipated in meeting this requirement.

A measure of the visual acuity of one subject (P.P.) was obtained utilizing one of the instruments available in the optics group of the Electronics and Bioengineering Laboratory of SRI. The measurement method involves forced-choice discrimination on the part of the subject between alternate zero and finite-contrast grating images, for each of a number of spatial-frequency gratings. (See Appendix II.)

The system, which is automated, tracks and records the subject's forced-choice responses to yield a curve of threshold (75% correct choice) contrast sensitivity as a function of spatial frequency. As might be expected, higher contrast is required at the low and high frequency tails of the distribution, as compared with the middle range, to discriminate between grating and uniform images. The purpose of the test with regard to our program was to determine whether a subject possessing an unusual ability to view remote stimuli also possessed an unusual visual acuity response in a threshold-determining instrument, either because of unusual acuity in the ordinary sense, or through the use of an extraordinary ability to discriminate between a target and a blank under conditions of vanishingly-small information content.

The resultant curve lay within the range of expected human variation indicating no unusual response activity.

2. <u>Measurement Program</u>

A 10-channel polygraph facility under the direction of Dr. Jerry Lukas of the Sensory Sciences Research Center has been brought into the program and certain functions tailored to our specification. The facility will be used initially to monitor GSR, blood flow (plethysmograph), and EEG activity of subjects carrying out tasks involving perception of remote stimuli. For our purposes, the display of raw data has been augmented by a computer program which has been written and debugged to provide on-line 5-second averages of EEG activity in the theta, alpha, and beta bands. Discussions are now in progress on experimental protocols to be employed in the utilization of this facility.

EEG data taken prior to this program, but unanalyzed, has been subjected to analysis in an effort to determine whether a particular protocol was a viable instrument for defining correlates of remote perception. The description of the experiment and the results of the analysis is given in the EEG section of a paper submitted for publication to Nature, given here as Appendix I.

In an effort to determine the effects of motivation on paranormal functioning, the following test procedure has been initiated. One subject (P.P.) has completed 7075 trials on guessing the state of a four-stage electronic random target generator without monetary reward being associated with the scoring, and is now repeating the series with a monetary reward scaled to scoring. Upon completion of the series, the results will be analyzed to determine whether the difference between scoring under the two conditions is significant. The reward system, shown in Table 1, is scaled linearly with difficulty.

Table 1

REWARD SYSTEM FOR SCORING ON 25-TRIAL RUN, P=1/4 PER TRIAL

Nr. hits/25-trial run,N	Prob. of at least N hits	Reward
10	0.071	$ 1
11	0.030	2
12	0.010	5
13	0.0034	12
14	0.00092	35

FIGURE CAPTIONS

1. Target pictures and responses drawn by Uri Geller under shielded conditions.

2. Computer drawings and responses drawn by Uri Geller.
    a. Computer drawing stored on video display
    b. Computer drawing stored in computer memory only
    c. Computer drawing stored on video display with zero intensity

3. Occipital EEG spectra, 0 to 20 Hz, for one subject (H.H.) acting as receiver, showing amplitude changes in the 9 - 11 Hz band as a function of strobe frequency. Three cases: 0, 6, and 16 flashes per second (12 trial averages).

INTRODUCTION

In this paper we present results of experiments suggesting the existence of one or more perceptual modalities through which individuals obtain information about their environment, wherein this information is not presented to any known sense. Such perceptual abilities are often considered to be paranormal. The literature in the field[1-3] coupled with our own observations have led us to conclude that such abilities can be studied under laboratory conditions.

The phenomena we have investigated most extensively pertain to the ability of certain individuals to describe graphical material or remote scenes shielded against ordinary perception. In addition, we also performed pilot studies to determine if electroencephalographic (EEG) recordings might indicate perception of remote happenings even in the absence of correct overt responses.

In these experiments we concentrated on what we considered to be our primary responsibility--namely, to resolve under conditions as unambiguous as possible the basic issue of whether a certain class of paranormal perception phenomena exists. Therefore, we conducted our experiments with sufficient control, utilizing visual, acoustic, and electrical shielding, to ensure that all conventional paths of sensory input were blocked. At all times we were vigilant in the design of our experiments to take measures to prevent sensory leakage and to prevent deception, whether intentional or unintentional, on the part of our subjects.

The overall goal of our research program is the determination of the laws underlying these phenomena. That is, our goal is not just to catalog interesting events, but rather to uncover patterns of cause-effect relationships that lend themselves to analysis and hypothesis in the forms with which we are familiar in scientific study. The results presented here constitute a first step toward that goal, in that we have established under known conditions a data base from which departures as a function of physical and psychological variables can be studied in future work.

In this paper we describe three related experiments which we consider to represent a single ability exhibiting different rates of information transmission. First, we conducted experiments with Mr. Uri Geller in which we examined his ability, while located in an electrically shielded room, to reproduce target pictures drawn by experimenters located at remote locations. Second, we conducted double-blind experiments with two individuals, Mr. Ingo Swann and Mr. Pat Price, in which we measured their ability to describe remote outdoor scenes many miles from their physical location. Finally, we conducted preliminary tests using electroencephalograms (EEG), in which subjects were asked to perceive whether a remote light was flashing, and to determine whether a subject could perceive the presence of the light, even if only at a noncognitive level of awareness.

REMOTE PERCEPTION OF GRAPHIC MATERIAL

We describe here a series of experiments in paranormal perception with a 27 year old Israeli subject, Uri Geller. In preliminary testing Mr. Geller apparently demonstrated an ability to reproduce simple pictures in order to eliminate the possibility of pre-experiment target forcing, Mr. Geller was kept ignorant as to the identity of the person selecting the target and as to the method of target selection. Mr. Geller's task was then to reproduce with pen on paper the line drawing being generated by the experimenters at the target location. Following a period of effort ranging from a few minutes to half an hour, Mr. Geller either passed (when he did not feel confident) or indicated he was ready to submit a drawing to the experimenters, in which case the drawing was collected before Mr. Geller was permitted to see the target.

In order to prevent sensory cueing of the target information, Experiments 1 through 10 were carried out using a shielded room in SRI's facility for EEG research. The degree of acoustic and visual isolation provided for this experiment is that afforded by a double-walled steel room, locked by means of an inner and outer door, each of which is secured with a refrigerator-type locking mechanism. The person inside the room is continuously monitored by means of a one-way audio monitor. The target picture was never discussed by the experimenters after the picture was drawn or brought near the shielded room. In our detailed examination of the shielded room and the protocol used in these experiments, no sensory leakage has been found.

The conditions and results for the ten experiments carried out in the shielded room are displayed in Table 1. As indicated in the Table, all experiments, except Experiments 4 and 5, were conducted with Mr. Geller closeted inside the shielded room. In Experiments 4 and 5, the procedure was reversed--i.e., the target was located inside the shielded room, with (line drawings) which had been drawn and placed in opaque sealed envelopes which Mr. Geller was not permitted to handle. However, since each of the targets was known to at least one experimenter in the room with Mr. Geller, it was not possible on the basis of the preliminary testing to discriminate between Mr. Geller's direct perception of envelope contents and perception via some mechanism involving the experimenters, whether paranormal or subliminal.

Therefore, an experimental study was undertaken to examine the phenomenon under conditions specifically designed to eliminate all conventional information channels, overt or subliminal. This was accomplished by separating Mr. Geller from both the target material and anyone knowledgeable of the target material, as in the recent experiments by Musso and Granero.[4]

The first part of the study consisted of a series of thirteen separate drawing experiments carried out over a seven day period. The thirteen-experiment data set constitutes the entire set of consecutive experiments carried out in the time available for the study, with no experiments deleted.

The protocol for the experiments was as follows: At the beginning of the experiment either Mr. Geller or the experimenters entered a shielded room so that from that time forward Mr. Geller was at all times visually, acoustically, and electrically shielded from personnel and material at the target location. Only following Mr. Geller's isolation from the experimenters was a target chosen and drawn, a procedure designed to eliminate pre-experiment cueing. The method of target selection involved random procedures, such as randomly opening a dictionary and selecting the first word describing an object that could reasonably be drawn. Furthermore,

TABLE 1. SUMMARY: REMOTE PERCEPTION OF GRAPHIC MATERIAL

Experiment	Date	Geller Location	Target Location	Target	Figure
1	8/4/73	Shielded room #1[a]	Adjacent room (4.1 m)[b]	Firecracker	1a
2	8/4/73	Shielded room #1	Adjacent room (4.1 m)	Grapes	1b
3	8/5/73	Shielded room #1	Office (475 m)	Devil	1c
4	8/5/73	Room adjacent to shielded room #1	Shielded room #1 (3.2 m)	Solar system	1d
5	8/6/73	Room adjacent to shielded room #1	Shielded room #1 (3.2 m)	Rabbit	No drawing
6	8/7/73	Shielded room #1	Adjacent room (4.1 m)	Tree	No drawing
7	8/7/73	Shielded room #1	Adjacent room (4.1 m)	Envelope	No drawing
8	8/8/73	Shielded room #1	Remote room (6.75 m)	Camel	1e
9	8/8/73	Shielded room #1	Adjacent room (4.1 m)	Bridge	1f
10	8/8/73	Shielded room #1	Adjacent room (4.1 m)	Seagull	1g
11	8/9/73	Shielded room #2[c]	Computer (54 m)	Kite (computer CRT)	2a
12	8/10/73	Shielded room #2	Computer (54 m)	Church (computer memory)	2b
13	8/10/73	Shielded room #2	Computer (54 m)	Arrow through heart (computer CRT, zero intensity)	2c

[a] EEG Facility shielded room (see text).

[b] Perceiver-target distances measured in meters.

[c] SRI Radio Systems Laboratory shielded room (see text).

Mr. Geller on the outside in an adjacent room. For those experiments in which Mr. Geller was inside the shielded room, the target location was in an adjacent room at a distance of about 4 meters, except for Experiments 3 and 8, in which the target locations were, respectively, an office at a distance of 475 meters and a room down the hall at a distance of about 7 meters.

In Experiment 1, the object drawn on the basis of random dictionary selection was a firecracker, shown in Fig. 1(a). Mr. Geller's immediate verbal response via the audio monitor was that he saw "a cylinder with noise coming out of it." He made two responses to the target, also shown in Fig. 1(a).

In Experiment 2, the target--also chosen by random dictionary selection--was a cluster of grapes. Mr. Geller said that he was quite certain that he had the picture. Both the target picture and Mr. Geller's response have 24 grapes in the cluster (Fig. 1(b)).

In Experiment 3, Mr. Geller was locked in the shielded room with one experimenter outside as a monitor while the target was drawn in another building 475 meters away. The target, again randomly selected from the dictionary, was a devil (Fig. 1(c)). Mr. Geller spent 30 minutes on his drawing and expressed considerable difficulty in getting the target. The results are interesting from the standpoint of possible insight into the process that they provide. His drawings consisted of representations of Biblical symbology, including the "Moses tablets," an apple with a worm, a snake, and a concluding composite picture with the tablets on top of the world and the trident outside. Of these only the trident corresponds

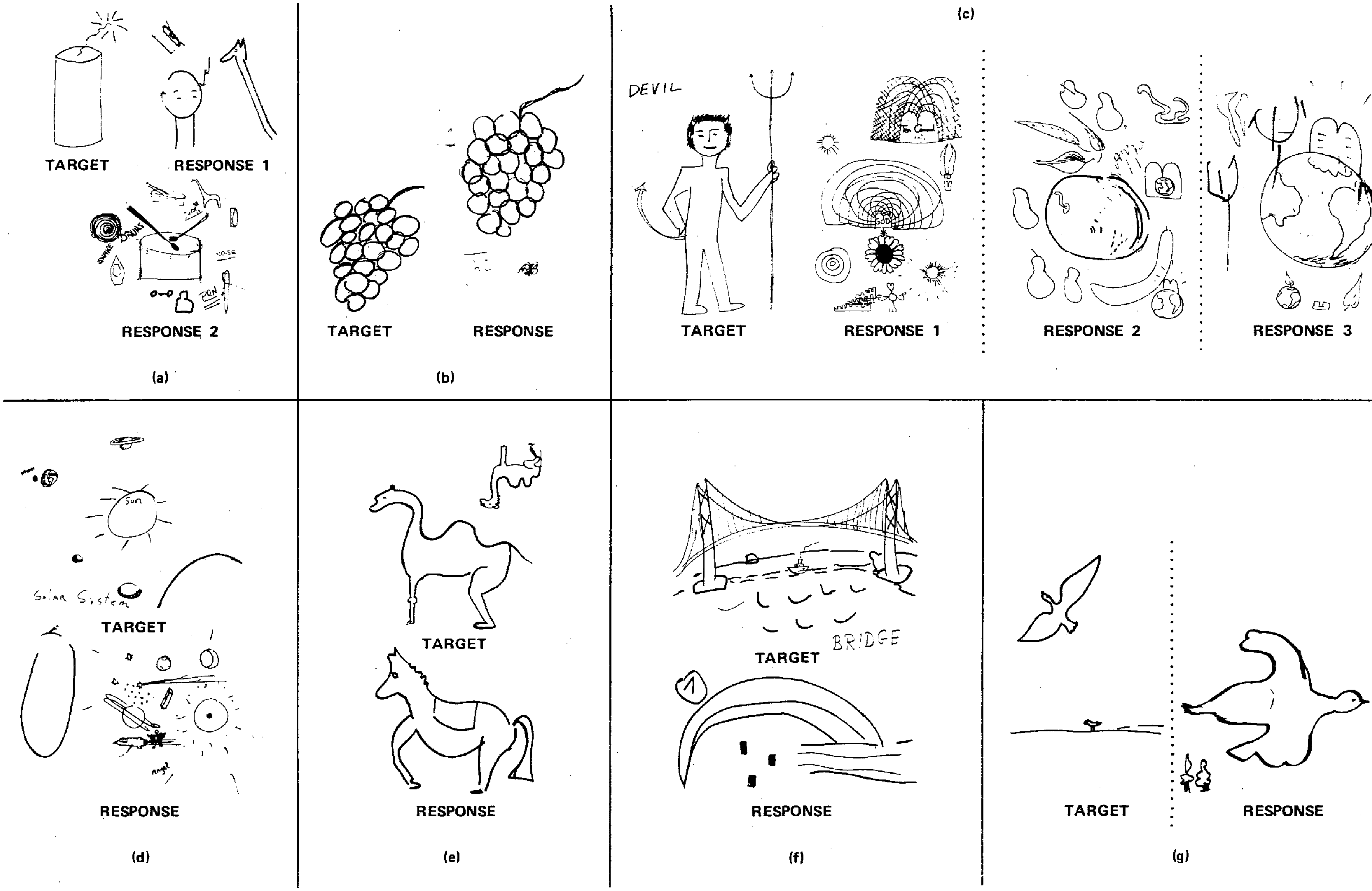

FIGURE 1 GRAPHICAL MATERIAL CONSISTING OF TARGET PICTURES AND RESPONSES DRAWN BY URI GELLER UNDER SHIELDED CONDITIONS

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directly to an element in the target drawing. One is led to speculate that the Biblical elements in these three drawings are perhaps associational material triggered by the target.

The target picture for Experiment 4 was drawn by an experimenter while he was inside the shielded room, with Mr. Geller outside the room with another experimenter. In this case the target (Fig. 1(d)) was a representation of the solar system. Mr. Geller's response to the target while outside the room coincides quite well with the target drawing.

In Experiment 5, the person-to-person link was eliminated by arranging for a scientist outside the usual experimental group to draw a picture, lock it in the shielded room before Mr. Geller's arrival at SRI, and leave the area. Mr. Geller was then led by the experimenters to the shielded room and asked to draw the picture inside the room. He said that he got no clear impression and therefore did not submit a drawing. The elimination of the person-to-person link was examined further in the second series of experiments with this subject, which is described later.

Experiments 6 and 7 were carried out while we recorded Mr. Geller's EEG during his efforts to perceive the target pictures. The target pictures were, respectively, a tree and an envelope. He found it difficult to hold adequately still for good EEG records, said that the experienced difficulty in getting impressions of the targets, and again submitted no drawings.

For Experiment 8, the target picture was a camel and Mr. Geller's response was a horse (Fig. 1(e)). In Experiment 9, the target was a bridge. Mr. Geller's drawing bears some resemblance to the target (Fig. 1(f)), but before seeing the target picture he stated that he did not know what the picture was.

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At the beginning of Experiment 10, Mr. Geller expressed extreme confidence and entered the shielded room. The target then chosen for Experiment 10 was a bird in flight. Mr. Geller said almost immediately, via the audio monitor in the shielded room, that he saw a swan flying over a hill and that he was sure that his drawing was correct (Fig. 1(g)).

Experiments 11 through 13 were carried out in SRI's Engineering Building, to make use of the computer facilities available there. For these experiments, Mr. Geller was secured in a double-walled, copper-screen Faraday cage 54 meters down the hall and around the corner from the computer room.†

For Experiment 11, a picture of a kite was drawn by one of the experimenters on the face of a cathode ray tube display screen, driven by the computer's graphics program. Mr. Geller's response, shown in Fig. 2(a), was a square with diagonals.

For Experiment 12, a picture of a church was drawn and stored in the memory of the computer. Mr. Geller's responses are shown in the drawings of Fig. 2(b). Although his responses have some elements in common with the target drawing, he did not recognize the target as a church.

In Experiment 13, the target drawing, an arrow through a heart (Fig. 2(c)), was drawn on the face of the cathode ray tube and then the display intensity was turned off so that no picture was visible. Mr. Geller immediately

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†The Faraday cage provides 120 dB attenuation for plane wave radio frequency radiation over a range of 15 KHz to 1 GHz. For magnetic fields the attenuation is 68 dB at 15 KHz and decreases to 3 dB at 60 Hz.

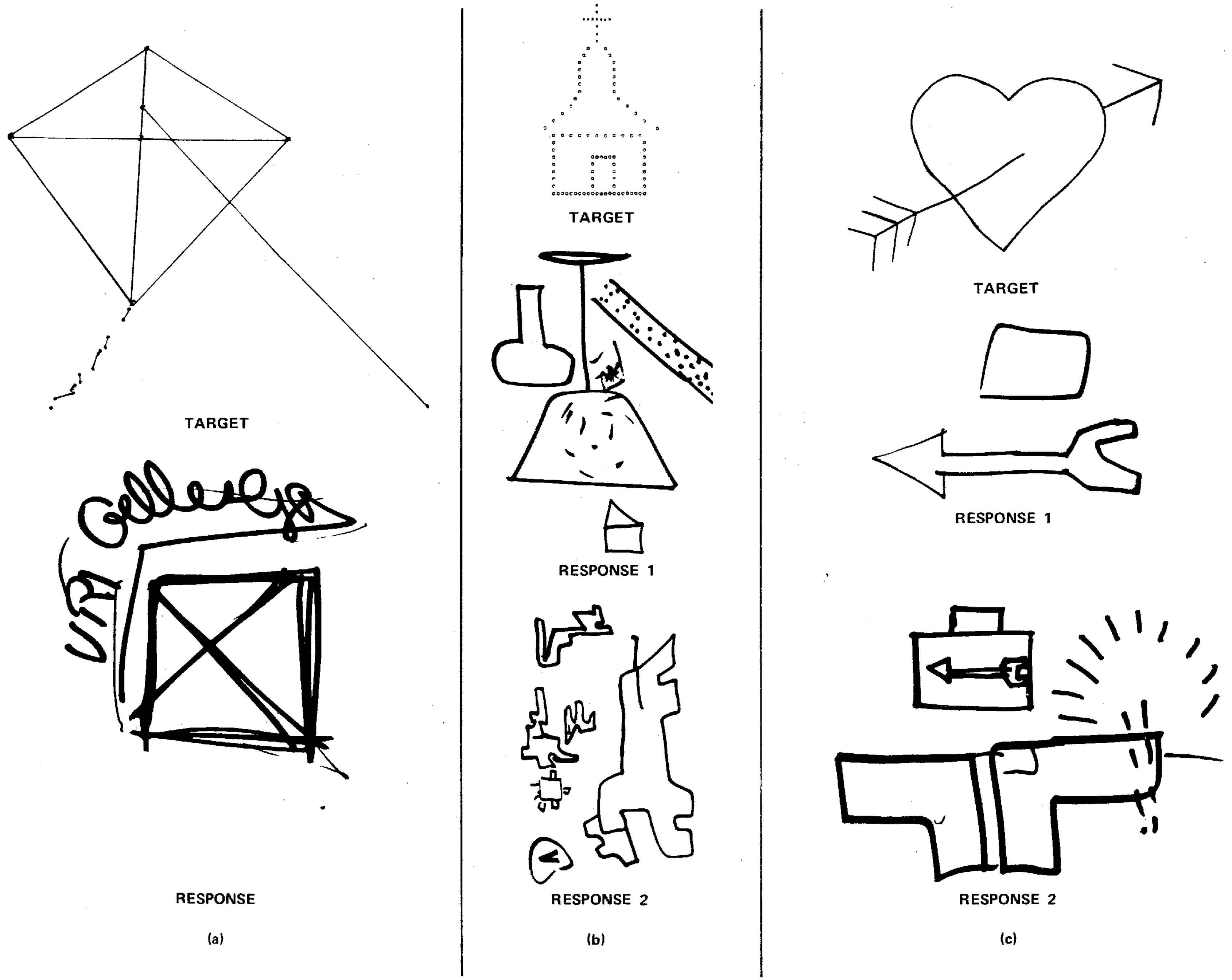

FIGURE 2 GRAPHICAL MATERIAL FROM COMPUTER DRAWING EXPERIMENTS WITH URI GELLER. (a) PICTURE STORED ON VIDEO DISPLAY. (b) PICTURE STORED IN COMPUTER MEMORY ONLY. (c) PICTURE STORED ON VIDEO DISPLAY WITH ZERO INTENSITY.

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drew an arrow under a rectangle and then drew another arrow inside a suitcase, which he considered a better representation of the target.

To obtain an independent evaluation of the correlation between target and response data, the experimenters submitted the data for judging on a "blind" basis by two SRI scientists who were not otherwise associated with the research. For the ten cases in which Mr. Geller provided a response, the judges were asked to match the response data with the corresponding target data (without replacement). In those cases in which Mr. Geller made more than one drawing as his response to the target, all the drawings were combined as a set for judging. The two judges each matched the target data to the response data with no error. For either judge such a correspondence has an a priori probability, under the null hypothesis of no information channel, of $p = (10!)^{-1} \cong 3 \times 10^{-7}$.

The quality of match between target and response in certain cases, together with the overall probability of matching obtained by the judges, constitute strong evidence for the existence of a potentially useful information channel.

A second series of experiments was carried out to determine whether direct perception of envelope contents was possible without some person knowing of the target picture.

One hundred target pictures of everyday objects were drawn by an SRI artist and sealed by other SRI personnel in double envelopes containing black cardboard. The hundred targets were divided randomly into groups of 20 for use in each of the three days' experiments.

On each of the three days of these experiments, Mr. Geller passed. That is, he declined to associate any envelope with a drawing that he made. On each day he made approximately 12 recognizable drawings, which he felt were associated with the entire target pool of 100. He seemed to be disturbed by the existence of such a large target pool. On each of the three days, two of his drawings could reasonably be associated with two of the 20 daily targets. On the third day, two of his drawings were very close replications of two of that day's target pictures. We consider that the drawings resulting from this experiment do not depart significantly from what would be expected by chance, which appeared to be Mr. Geller's conclusion also, leading to passes on his part.

Thus, it would appear that eliminating a person knowledgeable of the target degrades the quality of the information channel. However, based on Mr. Geller's subjective impression, there is also the possibility that advance preparation of a large target pool, in comparison with single target preparation,results in cross talk--i.e., diffuses the identity of the target.

In a simpler experiment Mr. Geller was successful in obtaining information in which no persons were knowledgeable of the target. A double blind experiment was performed in which a single die was placed in a small steel box. The box was then vigorously shaken by one of the experimenters and placed on the table. The orientation of the die within the box was unknown to the experimenters at that time. Mr. Geller would then write down his perception as to which die face was uppermost. Thus, in this case the target pool was known, but the targets were individually prepared in a manner blind to all persons involved in the experiment. This experiment was performed ten times, with Mr. Geller passing twice and giving a response eight times. In the eight times in which he gave a response, he was correct each time.[†] The probability of this occurring by chance is approximately one in a million, $(1/6)^8$.

To summarize the work with Mr. Geller,[5] we observe that in certain situations significant information transmission can take place under shielded conditions. Factors which appear to be important and therefore candidates for future investigation include whether the subject knows the set of targets in the target pool, the actual number of targets in the target pool at any given time, and whether the target is known by any of the experimenters.

REMOTE VIEWING OF NATURAL TARGETS

In experiments carried out in our program to investigate the abilities of a New York artist, Mr. Ingo Swann, he expressed the opinion that the insights gained during experiments at SRI had strengthened his ability to view remote locations that had been researched before he joined the SRI program.[6]

To test Mr. Swann's assertion, a pilot study was set up in which a

[†]The distribution of responses consisted of three 2s, one 4, two 5s, and two 6s.

series of targets from around the globe were supplied to the experimenters by SRI personnel on a double-blind basis. In our estimation, Mr. Swann's ability to describe correctly details of buildings, roads, bridges, and the like indicated that he could perceive remote locations, sometimes in great detail, given only their geographic latitude and longitude. Thus, we considered the descriptions were sufficiently accurate to warrant our setting up a research program in remote viewing.

We present here the results of a remote viewing experiment, carried out with a second subject in the remote viewing program, Mr. Pat Price, a former California police commissioner and city councilman. This experiment consisted of a series of double-blind, demonstration-of-ability tests involving local targets in the San Francisco Bay area which could be documented by several independent judges. We planned the experiment considering that natural geographical places or man-made sites that have existed for a long time are more potent targets for paranormal perception experiments than are artificial targets prepared in the laboratory. This is based on the opinions of Mr. Swann and Mr. Price that the use of artificial targets involves a "trivialization of the ability" as compared with natural pre-existing targets.

In each of nine experiments involving Mr. Price as remote-viewing subject and SRI experimenters as a target demarcation team, a remote location was chosen in a double-blind protocol. Mr. Price, who remained at SRI, was asked to describe this remote location, as well as whatever activities might be going on there.

Data from the nine experiments are presented in the following paragraphs. Final judging indicated that several descriptions yielded significantly correct data pertaining to and descriptive of the target location.

REMOTE VIEWING PROTOCOL

In the nine double-blind remote-viewing experiments, the following procedures were used. An experimenter was closeted with Mr. Price at SRI to wait 30 minutes to begin the narrative description of the remote location. The SRI locations from which the subject viewed the remote locations consisted of an outdoor park (Experiments 1,2), the double-walled copper-screen Faraday cage discussed earlier (Experiments 3, 4, 6-9), and an office (Experiment 5).

A second experimenter would then obtain a target location from an individual in SRI management, the director of the Information Science and Engineering Division, not otherwise associated with the experiment. This location was either in the form of traveling orders previously prepared, sealed, and randomized by the target selecter (Experiments 1, 2, 5, 6), or by his driving the target demarcation team to the target himself without any written indication (Experiments 3, 4, 7-9). The set of targets was chosen from a target-rich environment by asking the selector to use his judgment in providing a set of nine target locations which were clearly differentiated from each other and within thirty minutes driving time from SRI. In all cases, the target demarcation team proceeded directly to the target by automobile without communicating with the subject or experimenters remaining behind. Since the experimenter remaining with the subject at SRI was in ignorance both as to the particular target and also as to the target pool, he was free to question Price to clarify his descriptions. The demarcation team then remained at the target site for an agreed-upon thirty minute period following the thirty minutes allotted for travel. During the observation period, the remote-viewing subject would describe his impressions of the target site into a tape recorder. A comparison was then made when the demarcation team returned. To represent best the detail and style of these narratives, we have included the entire unedited text of one of the better narratives containing very few incorrect statements, Experiment 7, in an appendix.

In general, the descriptions contained inaccuracies as well as correct statements. To obtain a numerical evaluation of the accuracy of the remote viewing experiment, the nine original target locations were subjected to independent judging on a blind basis by five SRI scientists who were not otherwise associated with the research. The judges were asked to match the nine locations, which they independently visited, against the typed manuscripts of the tape-recorded narratives of the remote viewer. The transcripts were unlabeled and presented in random order. The judges were asked to find a narrative which they would consider the best match for each of the places they visited. A given narrative could be assigned to more than one target location. The hypothesis is that the judges, when asked to match the actual targets with the transcripts, would place the actual target in the most favored category more often than they would be expected to by chance. Table 2 shows the distribution of the

DESCRIPTIONS CHOSEN BY JUDGES		PLACES VISITED BY JUDGES								
		1	2	3	4	5	6	7	8	9
Hoover Tower	1	ABC DE				D				
Baylands Nature Preserve	2		ABC	E				D		D
Radio Telescope	3			ACD		BE				
Redwood City Marina	4		CD		ABD E		E			
Bridge Toll Plaza	5						ABD		DCE	
Drive-In Theatre	6			B		A	C			E
Arts and Crafts Garden Plaza	7							ABC E		
Church	8				C				AB	
Rinconada Park	9		CE							AB

TABLE 2. Distribution of correct selections by Judges A, B, C, D, and E in remote viewing experiments. Of the 45 selections (5 judges, 9 choices), 24 were correct. Boxes heavily outlined indicate correct choice.

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judges' choices. For purposes of display we present the table such that the main diagonal corresponds to the correct choices. The number of correct matches by judges A through E is 7, 6, 5, 3, and 3, respectively. The expected number of correct matches from the five judges was five; in the experiment twenty-four such matches were obtained.

Among all possible analyses, none is more conservative than a permutation analysis of the majority vote of the judges' selections assuming assignment without replacement. By majority vote, six of the nine descriptions and locations were correctly matched. Under the null hypothesis (no remote viewing and a random selection of descriptions without replacement), this outcome has an _a priori_ probability of $p = 5.6 \times 10^{-4}$, since, among all possible permutations of the integers one through nine, the probability of six or more being in their natural position in the list has that value. Therefore, although Price's descriptions contain inaccuracies, the descriptions are sufficiently accurate to permit the judges to differentiate among the various targets to the degree indicated.

EEG EXPERIMENTS

An experiment was undertaken to determine whether a physiological measure such as EEG activity could be used as an indicator of information transmission between an isolated subject and a remote stimulus. We hypothesized that perception could be indicated by such a measure even in the absence of verbal or other overt indicators.[7,8] In other words, this experiment examines the hypothesis that perception may take place at noncognitive levels of awareness and be measurable, even though not expressed verbally.

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.[9] We hypothesized that if we stimulated one subject in this manner (a sender), the EEG of another subject in a remote room with no flash present, (a receiver), might show changes in alpha (9-11 Hz) activity, or possibly EEG driving similar to that of the sender.

Applying this concept, 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 the visually opaque, acoustically and electrically shielded double-walled steel room previously described. The sender was seated in a room across the hall from the EEG chamber at a distance of about 7 meters from the receiver.

In order to find subjects who were responsive to such a remote stimulus, we initially worked with four female and two male volunteer subjects, all of whom believed that success in the experimental situation might be possible. 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 meter in front of the sender was used to present flash trains of 10 sec duration. The receiver's EEG activity from the occipital region (O_Z), referenced to linked mastoids, was amplified with a Grass 5P-1 preamplifier and associated driver amplifier with a bandpass of 1 to 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 ten-second train of flashes or a null flash interval presented to the sender. Thirty-six such trials were given in an experimental session, consisting of 12 null trials--i.e., no flashes following the tone--12 trials of flashes at 6 fps, and 12 trials of flashes at 16 fps, all randomly intermixed. Each of the trials generated an 11-second EEG epoch. The last 4 seconds of the epoch was selected for analysis to minimize the desynchronizing action of the warning cue. This 4-second 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. However, of the six subjects studied initially, one subject (H.H.) showed a consistent alpha blocking effect. We therefore undertook further study with this subject.

Data from 7 sets of 36 trials each were collected from this subject on three separate days. This comprises 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.

Of our six subjects, H.H. had by far the most monochromatic EEG spectrum. Figure 3 shows an overlay of the three averaged spectra from one of this subject's 36-trial runs, displaying changes in her alpha activity for the three stimulus conditions.

Mean values for the average power and peak power for each of the seven experimental sets were given in Table 3. The power measures were less in the 16 fps case than in the 0 fps in all seven peak power measures and in six out of seven average power measures.

Siegel's two-tailed $\underline{t}$ approximation to the nonparametric randomization test[10] 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 fps was significantly less than when there were no flashes ($t = 2.09$, df = 118, $p < .04$). The second measure, peak power, was also significantly less in the 16 fps conditions than in the null condition ($t = 2.16$, df = 118, $p < .03$). The average response in the 6 fps condition was in the same direction as that associated with 16 fps, but the effect was not statistically significant.

Spectrum analyses of control recordings made from saline with 12K ohms resistance in place of the subject with and without the addition of a 10 Hz, 50 μV test signal applied to the saline solution, revealed no indications of flash frequencies, nor perturbations of the 10 Hz signal. These controls suggest that the results were not due to system artifacts.

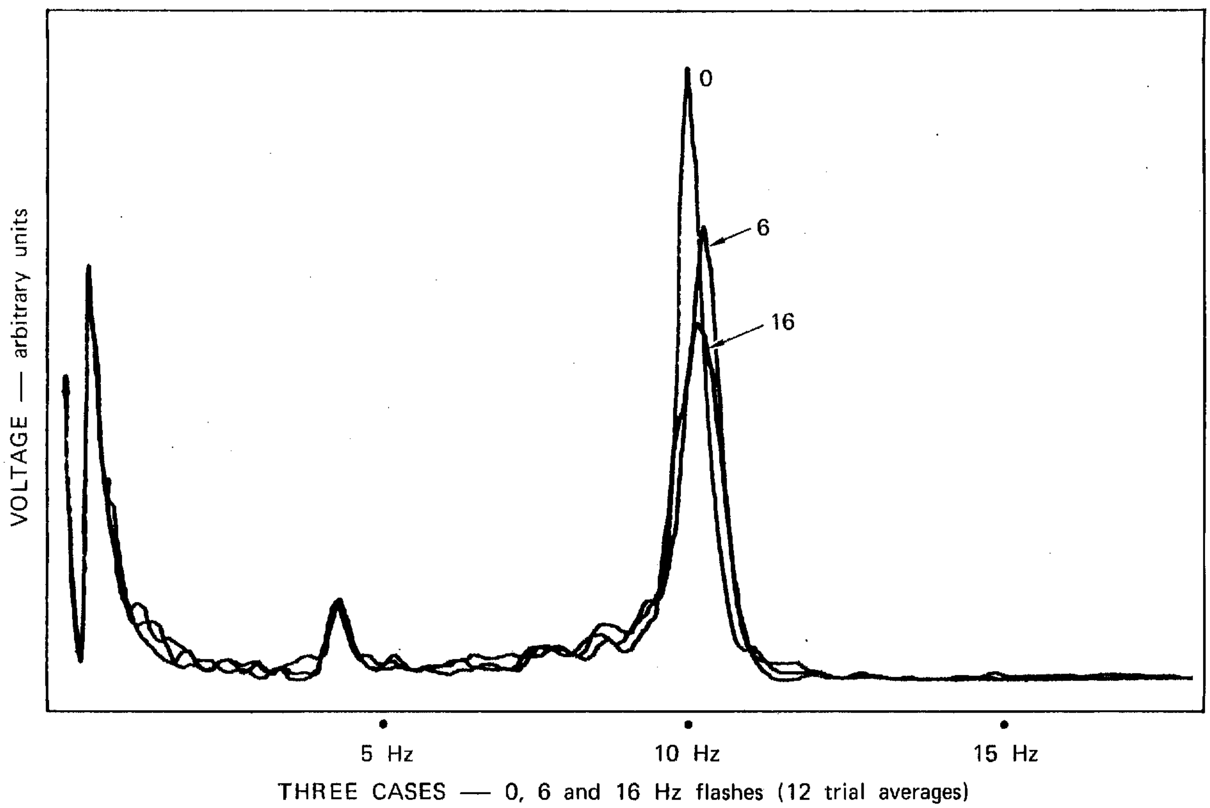

FIGURE 3 OCCIPITAL EEG FREQUENCY SPECTRA, 0 TO 20 Hz, OF ONE SUBJECT (H.H.) ACTING AS RECEIVER SHOWING AMPLITUDE CHANGES IN THE 9-11 Hz BAND AS A FUNCTION OF STROBE FREQUENCY

Flash Frequency / Sender	Average Power 0	Average Power 6	Average Power 16	Peak Power 0	Peak Power 6	Peak Power 16
J.L.	94.8	84.1	76.8	357.7	329.2	289.6
R.T.	41.3	45.5	37.0	160.7	161.0	125.0
No Sender (Subject informed)	25.1	35.7	28.2	87.5	95.7	81.7
J.L.	54.2	55.3	44.8	191.4	170.5	149.3
J.L.	56.8	50.9	32.8	240.6	178.0	104.6
R.T.	39.8	24.9	30.3	145.2	74.2	122.1
No Sender (Subject not informed)	86.0	53.0	52.1	318.1	180.6	202.3
Averages	56.8	49.9 -12%	43.1 -24% (P<.04)	214.5	169.8 -21%	153.5 -28% (P<.03)

TABLE 3. EEG data for H.H. showing average power and peak power in the 9 - 11 Hz band, as a function of flash frequency and sender. Each table entry is an average over 12 trials.

Further tests also gave no evidence of radio frequency energy associated with the stimulus.

Subjects were asked to indicate their conscious assessment for each trial as to which stimulus was generated. They made their guesses known to the experimenter via one-way telegraphic communication. An analysis of these guesses has shown them to be at chance, indicating the absence of any supraliminal cueing.

Thus, we note that in this pilot study, one of six subjects showed significant EEG changes associated with the presence of remote stimuli under conditions of sensory shielding. This form of noncognitive arousal evidenced by alpha blocking has also been observed by Tart (1963), using a small electric shock stimulus applied to himself as sender in a similar experiment.[7] We hypothesize that the protocol described here may prove to be useful as a screening procedure for latent remote perceptual ability in the general population.

DISCUSSION

We have presented evidence for the existence of a biological information channel whose characteristics appear to fall outside the range of known perceptual modalities. The precise nature of the channel or channels is as yet undefined, but may involve either direct perception of hidden information content, perception of mental images of persons knowledgeable of target information, precognition, or some combination of these or other information channels.

We have worked with three individuals, two of whom are reported on in detail here, whose remote perceptual abilities were sufficiently developed that they were able to describe both pictorial and geographical material blocked from ordinary perception.

In addition to experiments which centered on subjects' conscious perceptions, we have also conducted EEG experiments in which we have found statistically significant evidence of direct physiological indications of nonconscious perception of remote stimuli. The observation that a nonconscious link with physiological correlates can exist between separated individuals is one that merits considerable study.

From these experiments we conclude that

- A channel exists whereby information about a remote location can be obtained by means of an as yet unidentified perceptual modality.
- As with all biological systems, the information channel appears to be imperfect, containing noise along with the signal.
- While a quantitative signal-to-noise ratio in the information-theoretical sense cannot as yet be determined, the results of our experiments indicate that the functioning is at the level of useful information transfer.

It may be that remote perceptual ability is widely distributed in the general population, but because the perception is generally below an individual's level of awareness, it is repressed or not noticed. For example, two of our subjects (H.H. and P.P.) had not considered themselves to have unusual perceptual ability before their participation in these experiments. We conjecture that it is partially the prevailing philosophical attitudes of the times in which we live that prevent such ability as may exist from surfacing to a greater extent. Our shared cultural constraints deny permission for the demonstration of such abilities.

With regard to the methodology itself, our observation of the phenomena leads us to conclude that experiments in the area of so-called paranormal phenomena can be scientifically conducted. The results presented here offer a basis from which departures as a function of other observables can be studied. Our goal for future experimentation is the investigation of the physical and psychological laws underlying these phenomena, rather than just the addition of further demonstrations of the statistical appearance of paranormal phenomena in the laboratory.

ACKNOWLEDGMENTS

This research was sponsored by The Foundation for Parasensory Investigation, New York City. We wish to thank its president, Mrs. Judith Skutch, and their representative, Dr. Edgar D. Mitchell of the Institute of Noetic Sciences--as well as our SRI associates, Mr. Bonnar Cox, Mr. Earle Jones, and Dr. Dean Brown--for their support and encouragement throughout this work. We also wish to acknowledge Dr. Wilbur Franklin of Kent State University for his contribution, especially in the early phases of this research. Finally, we acknowledge the many constructive suggestions provided us through conversations with Mrs. Jean Mayo, Dr. Charles Tart, University of California, and Dr. Robert Ornstein and Dr. David Galin of the Langley Porter Neuropsychiatric Institute.

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APPENDIX

Following is the unedited transcript of remote viewing Experiment 7, where the target was an Arts and Crafts Garden Plaza. This is a large plaza resembling a California mission. There are craft shops around the perimeter of the plaza. In the plaza area are many gardens, flowers, ceramic pots, fountains, and paths. Overhead are vines on arbors of redwood. Price's description is accurate in almost every detail and he omitted little of importance.

1:40 THIS IS A REMOTE VIEWING EXPERIMENT WITH PAT PRICE, DEAN BROWN, AND RUSSELL TARG IN THE SHIELDED ROOM IN BUILDING 30. THE TRAVELLERS TO REMOTE LOCATION ARE BART COX, HAL PUTHOFF, JUDY SCHMICKLEY AND PHYLLIS COLE. WE EXPECT THE TRAVELLERS TO BE AT THEIR PLACE IN ABOUT 10 MINUTES.

IT'S 1:58. OUR TRAVELLERS SHOULD BE NEAR TO ARRIVING AT THE PLACE.

OK. Why don't I start scanning by quadrant using this as a center point. 12-3, 6-9......

I'll go from 12-3 first. Seems to me right now that I'm picking them up in the 12-3 quadrant, but I'll go on in the rest and look. I haven't actually identified them, I just feel that they're there.

Nope, I don't get them there.

Now I'll go from 6-9. While I was looking at 6-9, it looks to me like I'm looking at an iris, a flower of some kind. I'll come back and identify that later. Just wanted to get it down as having a flash of an iris flower-purplish. I'll continue to scan that quadrant. Nope, don't get them there.

I'll go from 9-12. Don't get them there.

I'll go back 12-3. Yeah, I get them in that quadrant.

Now I'll see if I can locate them physically and identify the area.

I'm looking at something that looks like an arbor, trellis-work arbor. Seems to be cool, shaded. Doesn't seem to me that they're out in the direct sunlight. Be more like there's lots of trees, in an arbor area.

The arbor appears to be made of wood, possibly redwood.

They're just....looks like it's a dirt path, quite wide, I'd say maybe 12 feet. I can see some grass. Looks like possibly a fountain of some kind.

Yeah, I can see Bart in his red shirt and what looks like kind of a gray paisley tie - I didn't really look at that when he was down there. The red shirt, I did. Looks like he has on a gray paisley tie.

It appears they're walking along quite leisurely.

Looks like there's some red brick laid into a walkway. They don't seem to be on it, they just seem to pass over that.

I get - it seems like a little ways away from them there are quite a few people but right where they're walking it doesn't appear to be many right in there.

This is an arbor area. Back of that arbor, back here I'd say 50 feet from that arbor to here, seems to be a lot of people in here. They were walking along here on what looks like about a 12 foot dirt path.

WHAT KIND OF PLACE IS THE ARBOR IN? IS IT A FIELD OUT IN THE OPEN?

No, I want to say park, but it doesn't exactly feel like a park. If you took a - the feeling I'm getting - it's not the specific place - but like the Town and Country Market. That type of an atmosphere, with quite a section of it into a little outdoor park, but basically I'm getting a very strong feeling of flowers.

Like the first one I saw was an iris.

TELL ME ABOUT THE TOWN AND COUNTRY ASPECT. IN WHAT WAY DOES IT REMIND YOU OF TOWN AND COUNTRY.

The buildings, not right where they're at, but very close to them have that same kind of architecture and look. The parking lot looks similar, grand, sweeping, not cluttered, it's more expansive area. You take a place like Sears Mall - it seems cluttered. This seems more leisurely paced.

People are moving about slower - there's not the hustle and bustle - more or less meandering.

TOWN AND COUNTRY MEANS TO ME A COVERED WALKWAY.

Yeah, the back of them it seems to be - where they are seems to be a very large arbor like vines growing over it and things, and there possibly - I haven't looked in there yet to see if there's any displays like pottery and things - I get the feeling that there is right close to it.

ALSO, OUTDOORS?

Yeah, it seems like fairly high shade trees - kinda bordering. The center part doesn't seem to have it - this part in here. The trees seem to be way up in here along like this over here. This seems to be shaded in here, but it's sunny out here.

I just saw something that looked like a windmill - not a farm type windmill - a Dutch-type windmill. It's smaller - it's not a huge thing, but I'm getting a definite feeling that it's like a windmill.

The area in there feels damp - not wet - they're not walking in water, but it's very moist.

The temperature in there...it's secluded. Feels very comfortable. A little on the shady side.

WHAT DO YOU FIND AS THE BOUNDARIES OF THE PLACE THEY'RE AT?

Outside of this little park-like affair that they seem to be in, there's a street. One side of it seems to be a kind of a residential...the other seems to be a little bit more heavily travelled.

Let me pick up a little bit more.

I can see one very large oak tree - exceptionally large.

Right now Bart is trying to point something out that is basically the significance of the whole place. It's like that key thing, well, if you'd have mentioned a salt pile I'd have blown my lid. Well, this has a significance that's just about comparable to that. I'm screening it out.

Thing that just flashed in was kind of like a stadium structure - like looking down into a stadium.

Just when I did that I - I'll have to reorient to make sure I'm looking in the same area now.

Seems like they're - I still get them in the same quadrant I had them in originally. Seems like some decorative brick walls.

THE QUADRANT YOU HAD THEM IN IS BASICALLY THE NORTHEAST QUADRANT?

Yeah, I got them out about this far - it's not far away - I'd say in this direction over here about - feels like a mile to a mile and a half. They don't feel as far away, and I'm not looking at the time continuum. They actually don't feel as far away. I'd say that it is about - not half the distance they were to the marina, and it seems to be on a line just about in that direction but just a hair more - rather than a direct line from here to the marina - they seem to be just slightly more to the left of that line.

I was looking back to where he had the car parked and it seems like it's on asphalt then a curb in front, and then it's like a dirt walkway and then a sidewalk. But I can see eucalyptus buds on the ground and some branches of eucalyptus there.

One of the most dominant things to me in the way of unusualness is the size of the oak tree that I'm looking at. Looks like an arboretum, or I get the definite feeling of flowers.

Almost get the feeling like it's commercial flowers.

In fact, the most predominant feeling that I'm getting right now is flowers.

Don't know why iris particularly.

There's something about the windmill that I was going to look at. Wasn't that what you were....?

Be like one you'd almost see in a miniature golfcourse...the windmill.

Has all the construction and detail but not as large - it's fairly small. Seems to be made out of dark redwood and it's kind of aged.

I'm going to try to look more directly to them. Let's see, there's Bart and Hal, and behind Bart is Judy and behind Hal is Phyllis, kinda staggered there.

Looks like a possible small pool of water - like a garden pond.

Looks like a little bridge.

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I was trying to get the feeling of what type of an area it was.

Let me elevate a bit. I'm looking at much too small an area. There's some greater significance there that I feel I'm definitely not looking at - let's jack up a bit...maybe 500 feet.

I see a lot of trees.

I see Judy's red hair and her brown eyes and her flashing teeth - she has beautiful teeth. Hadn't really looked at them before.

Phyllis and her are talking about something and Hal and Bart are talking about something and he's pointing at something and it seems to me that he's pointing over to what I'd call a windmill or something that looks like a windmill.

The water I see looks more like a pool or a pond than it does - you know, it's not big like a lake - not very large, but it looks like a definite pool.

Right where they're at I don't hear too much traffic noise - it seems to be fairly quiet.

Looks like a little wooden walkway.

Feels a little early, but it kinda seems like they're retracing their steps heading back toward the car, but they're still moving quite leisurely.

IF YOU LOOK DOWN ON THE PLACE FROM ABOVE, CAN YOU GET ANY FEELING FOR THE - IS THERE ANY OVERALL LAYOUT OR PLAN?

When I went up I could see trees and stuff, and I kind of got the feeling of like in a corner of a golf course, you know - where there would be a lot of trees overhanging the green and some things in there - that seemed to be out of context, but when I elevated, that's what I got. It kind of looked like an overlap to me, so I didn't talk about it, but I will.

When I elevated it kind of felt like it was right over the corner of a golf course of some kind, with a street running down one side, and they are fairly close to that.

In fact, the bricked area that I looked at or like a patio thing kinda looks like a walkway. Seems like there's small building - small meaning not tall - looks like a single story building. Looks like it has a flat roof - slightly pitched. Looks like 4 x 4 poles supporting it - has a canopy out over it. They're painted white, place looks like very possible light yellow or cream color.

They're walking not too far from that. Still seems to me that they're on a dirt pathway.

In the area that they're in now I get flowers again - where before they kinda fell out of the flowers.

Looks like maybe 80-100 yards from where they are - looks like 2 guys on a motor scooter. They can see them.

WHAT WOULD YOU SAY IS THE INTEREST TO THIS PLACE? WHAT'S SPECIAL ABOUT THIS PLACE?

It seems to be a kind of a recreational, relaxed...not energetic - looks more relaxed. I'd say it's kind of combination recreational and relaxation area that I'm getting out of it.

That would be the general character of it.

Two aspects - one is aesthetics and the other is a kind of a mild recreational area.

There seem to be some unique features - I don't have it totally into context as yet. There's a number of things that I've rejected - looked at and rejected saying.

First, I got the impression that it was kind of like a miniature golf course - I rejected that. Merely from saying it - I didn't reject the principle - I just rejected saying it.

Then I kind of got the idea of a standard golf course - I also rejected that on the same principle, so I'm just trying to describe the terrain.

Seems expansive - doesn't seem cluttered.

Just got a flash of something that reminded me of the gyroscope - gimbals on the gyroscope.

Drinking fountain - looks like it's made out of kinda like field stone built up into a fountain...bowl.

I'm going to elevate again and go through a search quadrant again.

I still get them in that general location, so that seems to set all right.

Distance - maybe a mile, mile and a half. Doesn't seem much farther- seems fairly close.

The area has an awful lot of grass, lot of trees - looks like dirt walk-ways, well trimmed. I can see the arbor, and the arbor could be a place to sit and be out of the direct sun.

May be a few little tables and benches and chairs in there.

That outlooks over quite a grassy area - there are quite a few trees. I see basically an oak.

Right after they got out of the car I could see some eucalyptus buds and branches on the ground, and it seemed like the trees were there.

Looked like they got out of the car, stepped upon a curb, dirt parkway, a sidewalk, and then they went into this area.

I get the feeling this windmill type thing - that all seems fairly real.

The feeling is still that it's relaxing and has some recreational aspects - I just haven't put it totally together as to giving it a name.

Right now I get a very strong impression of flowers again.

It seems like right now they're back to right where I originally spotted them only they're going in the opposite direction - like they're moving toward the direction they originally went.

While they were there they walked on several pathways - walked out quite a ways, then swung over and come over and worked around and looked at...

One peculiar thing I might note - so far I haven't sensed, seen nor heard an airplane.

Cars seem quite distant - outside of that little motor scooter affair with the two guys on it. That's about the only vehicular traffic I've seen - except out in the parking lot.

It seems like to me that they've got most of their attention off what they were looking at and they've got their attention more on the car now.

I want to look and find out what the significant thing was that Bart was talking about.

There's something quite unusual there and I ... Dammed if I can pick it up.

WAS HAL DOING ANYTHING BESIDES WALKING ALONG - WAS THERE ANY ACTIVITY FOR HAL TO DO?

Most of the time I was looking at Hal,he was kind of listening to Bart and Bart was pointing out a number of things.

Part of the time Bart was walking with Hal; part of the time he was back by Judy.

When I first saw them, it was Bart in the front on the left side, Hal was on his right, Judy was slightly behind - almost between Bart and Hal but behind, and Phyllis to her right.

They wandered around but the first time I picked up - they were that way.

When they were coming back, they just about reversed. Bart would be in front. When they were coming back, it looked like Bart was in front with Phyllis, and Judy was walking more behind Bart and Hal on her right when they were coming back out of there.

They're actually at the car.

2:30 SHALL WE GO DOWNSTAIRS AND SEE HOW THEY'RE DOING?

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A study of sine-wave contrast sensitivity by two psychophysical methods*

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In the literature on visual contrast thresholds for sine wave gratings, little attention has been paid to the psychophysical methods used to obtain these spatial-frequency response curves. Here we report a comparison of such data obtained by two quite different psychophysical methods, but otherwise under identical conditions, using five Ss. Both experiments were run by computer: (1) In the method of adjustments, the computer program merely controls the order of the stimuli and records S's contrast settings. (2) In the forced-choice staircase (FCS) technique, the program determines how often S can discriminate the sinusoidal grating from a uniform field, informs S of his accuracy, controls the stimulus contrast on the basis of S's preceding responses, and brackets his threshold by a series of successive approximations. Method 2 eliminates criterion effects that occur in Method 1, and hence tends to minimize individual differences. However, the FCS technique requires an order of magnitude more observing time to obtain equally smooth contrast sensitivity curves. FCS also increases the overall sensitivity of some Ss by as much as five times, but it does not significantly change the *shape* of the contrast sensitivity curve; both methods show strong effects of lateral inhibition at low spatial frequencies.

Measurements of the contrast threshold for a sinusoidal grating as a function of its spatial frequency have been used to study the effects on the visual process of optical, neural, chromatic, temporal, and other factors. Van Meeteren (1966) has reviewed a number of these studies. We are particularly interested in the low-frequency region of such data, below about 2 cycles/deg (cpd), because the monotonic increase of contrast sensitivity with increasing spatial frequency in this region may represent a simple form of lateral inhibition (Kelly, 1973).

In certain cases, little or no low-frequency falloff was reported (e.g., Westheimer, 1960; Campbell & Green, 1965), but this has been attributed to the use of small, sharp-edged targets (Davidson, 1966; Kelly, 1970) or flash presentations (Kelly, 1971, 1973), which are unsuitable for isolating the steady-state response to very low spatial frequencies. However, some Ss report that the task of detecting a low-frequency grating seems different from the high-frequency detection task; this raises the question of whether the apparent inhibition would persist at low frequencies if criterion effects were eliminated.

Many of the data in the literature have been obtained by the psychophysical method of adjustments, which is the easiest and fastest procedure when Ss are experienced in this type of judgment; variations of the method of limits have also been used. But more sophisticated psychophysical methods have been developed in recent years which are essentially independent of threshold criterion; these have not been applied to the measurement of sine wave contrast thresholds. We therefore undertook to compare the sine wave thresholds obtained by the method of adjustments with those obtained by a forced-choice staircase (FCS) paradigm, in which the S was always informed of the correctness of his choice. Our main purpose was to find out whether the low-frequency inhibition was independent of criterion effects, but our results are also relevant to other sine wave contrast experiments that use subjective judgments.

*Our work was partly supported by NIH Grant No. NS-08322 and NSF Grant No. GB-11571. Some of the data were reported at the October 1971 meeting of the Optical Society of America in Ottawa, Canada. We thank T. N. Cornsweet for suggesting this study.

METHODS

The stimulating apparatus is described in detail elsewhere (Kelly, 1966, 1972); its components are shown schematically in Fig. 1. S is seated comfortably, viewing a cathode ray tube (CRT) 50 cm distant through an artificial pupil, 2.3 mm in diam. He sees an 8-deg circular field, filled by a vertical sinusoidal grating. The spatial frequency of this grating is controlled by a (LINC 8) computer. The dependent variable is the Michelson contrast (m) of the grating, defined as

$$m = \frac{B_{max} - B_{min}}{B_{max} + B_{min}}$$

where B_{max} and B_{min} are the maximum and minimum values of the stimulus waveform, in trolands (td) of retinal illuminance. This contrast is under the control of either the computer or the S, depending on the mode of operation. Since the grating does not flash or flicker in the present experiments, our temporal waveform source was not used (see Fig. 1).

Adjustments Mode

In the method of adjustments, the S controls the contrast of the grating, using a geared-down potentiometer without stops or other mechanical cues. Spinning the knob about 1,200 deg covers the entire adjustment range, which may be either 0-1 or 0-0.1 contrast, depending on a switch controlled by the S. Another switch gives him the option of viewing zero or full contrast at any time, without losing his potentiometer setting. When the setting meets his threshold criterion, he pushes a

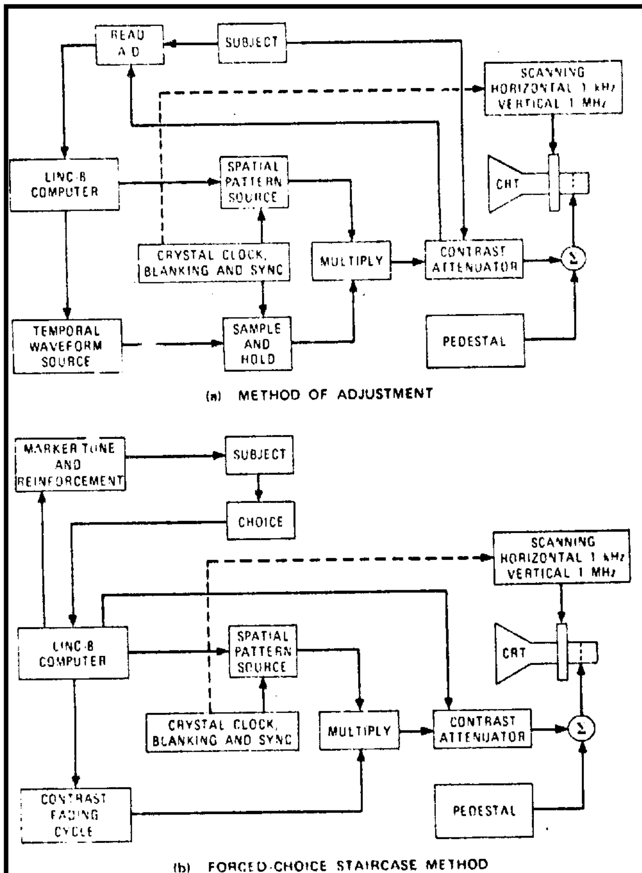

Fig. 1. Signal-flow diagrams of the CRT stimulator. (a) Configuration for method of adjustments. (b) Configuration for forced-choice staircase (FCS) procedure.

button which enters this contrast into the computer.

He is instructed to fixate the center of the grating and to find the contrast at which it can just be discriminated from a uniform field. (This criterion, which we always use for sine wave thresholds, should come close to matching S's performance in the forced-choice task described below.) S spends as much time as he wishes "hunting" back and forth to find his threshold, but we instruct him to make his final judgments only in the steady state; i.e., after he has refrained from changing the contrast for several seconds. Twelve spatial frequencies were tested in one experimental session; each pattern was presented five times in random order, for a total of 60 judgments. The means of these five settings gave fairly smooth spatial-frequency response curves, as described below. An experienced S can complete such a run in 20-25 min.

Forced-Choice Staircase (FCS) Mode

Our criterionless psychophysical procedure combined the staircase method of ordering stimuli (Békésy, 1947; Cornsweet, 1962) with the forced-choice method of response collection (Blackwell, 1946; Heinemann, 1961). In this application, the two techniques complement each other in such a way that S spends most of his time making discriminations near threshold.

The S's task is much simpler in the FCS mode. The same 12 stimulus patterns are used, but their contrast is now under the control of the computer. One stimulus cycle consists of two successive intervals, each 5 sec long; a pattern of nonzero contrast is presented in only one of these intervals, which is determined by the computer from a table of random numbers. One second after the beginning of each interval, a marker tone sounds to notify S that the stimulus may be visible. He makes his choice of interval by pushing a button, which also starts the next trial; but this button has no effect until after the second tone. In other words, S must make a choice in order to start a new trial, but he cannot do so until after the second interval has started. As soon as he makes his choice, he hears a pleasant tone (different from the marker tone) if he is correct or an unpleasant noise if he is not.

His only other control is a "pause" switch, which interrupts the experiment for rest periods. S may use this switch also to abort a given trial (if, for example, he happened to be looking away when the marker tone sounded). The aborted trial is repeated when the pause switch is reset, but the stimulus will not necessarily occur in the same interval.

In order to avoid transient effects (Kelly, 1971, 1973), as we do in the adjustments mode, the temporal waveform of the FCS stimulus is carefully controlled. The mean luminance of the CRT screen is held constant throughout the experiment. When a given pattern is presented, its contrast is smoothly "faded in" from zero to whatever value is set by the computer, as shown in Fig. 2a. The temporal envelope of the fade-in waveform resembles a half-cycle of a 0.5-Hz cosine wave, so that the full contrast of the pattern is present after 1 sec (this contrast always being zero in either the first or second interval, at random). The pattern is also faded out the same way.

All 12 staircases are independent and randomly interleaved, which helps to eliminate subjective bias effects (Cornsweet, 1962). On each trial, the contrast of the FCS stimulus is contingent on the correctness of the preceding responses to the same pattern, according to an algorithm described in detail in the Appendix. When the responses indicate that S can detect the pattern, the contrast is decreased; when he cannot, the contrast is increased, by a constant logarithmic increment in either case. Thus, the contrast is forced to cross and recross the threshold level (which is about 75% correct). At first, the size of the increment is decreased each time the response sequence indicates that a contrast increase has probably crossed S's threshold. But the third time this indication occurs, the smallest increment (30% contrast change) is maintained and the staircase is terminated with a fixed number of additional trials.

A typical staircase illustrating these properties is shown in Fig. 2b. Each stimulus is first presented at full contrast, to familiarize S with its appearance and to provide a suprathreshold baseline. If he detects it correctly, its next presentation is at a contrast of 0.02; the staircase then enters the main algorithm (see Appendix).

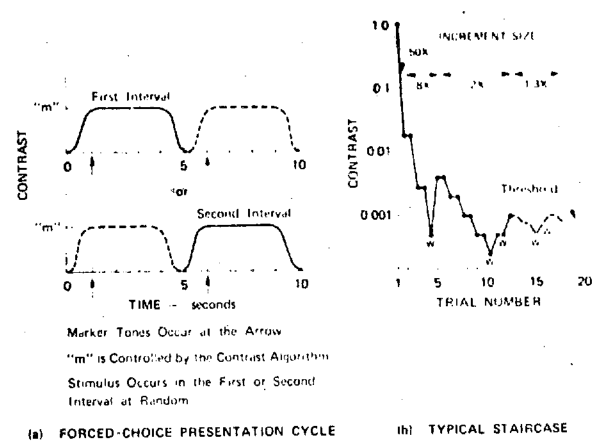

Fig. 2. Details of the FCS procedure. (a) Temporal waveform of one stimulus cycle and timing of alerting tones. (b) A single staircase, reassembled to show all contrasts presented, increment sizes, wrong responses, and calculated threshold.

Several hundred trials are required to terminate all 12 staircases; an experimental session usually takes 65-75 min, regardless of the skill or experience of the S. Most of the variability in length of the individual staircases (Rose et al, 1970) is averaged out by the large number of staircases being run simultaneously.[1]

The threshold for each pattern is calculated as the mean of the last eight contrasts presented, no adjacent pair of these being separated by more than the smallest increment. The intersession variability of FCS data obtained in this way is no greater than in the adjustment mode, but is mainly random rather than systematic. Thus, to obtain equally smooth spatial-frequency response curves, one must average the data from three FCS sessions, as described below.

RESULTS

Figure 3 shows some contrast sensitivity data obtained with a 20-year-old emmetropic naive S. The upper curve (filled circles) represents combined data from three FCS runs; three comparable adjustment curves are plotted separately (open circles). These data are typical of our results in three ways. First, the *shape* of the FCS curve is essentially the same as that of the adjustment curves; in both cases, the contrast sensitivity increases steeply at low spatial frequencies, to a maximum near 4 cpd. Second, the FCS sensitivity is systematically greater than that in any of the adjustment runs, by a factor of 2 to 5. Third, there are also systematic differences among the individual adjustment curves, but these are smaller than the FCS-adjustment differences.

The lowest sensitivity in Fig. 3 represents the first

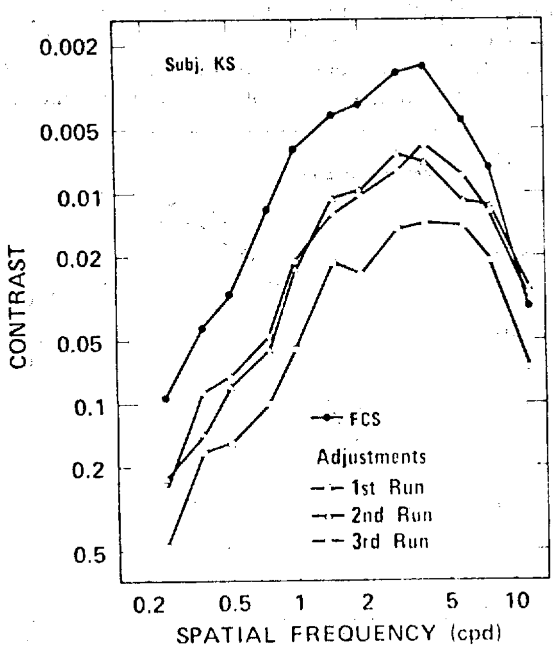

Fig. 3. Contrast sensitivity vs spatial frequency for S K.S. Retinal illuminance, 1,300 td; artificial pupil, 2. mm. Filled circles are the means of three FCS runs. Open circles represent three successive adjustment runs.

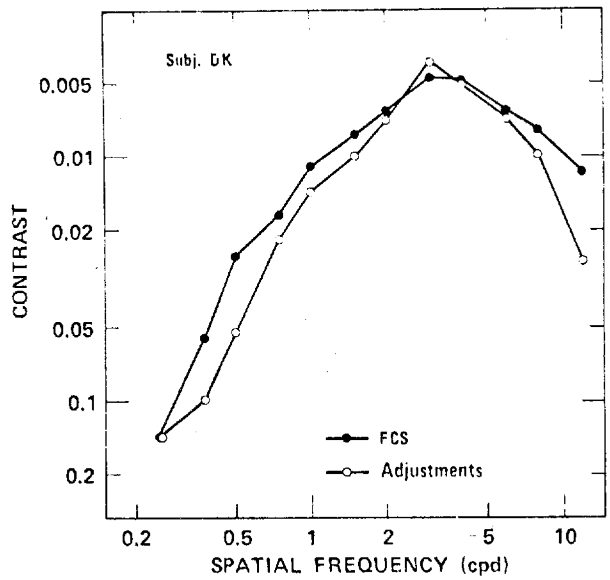

Fig. 4. Contrast sensitivity vs spatial frequency for S D.K. Same conditions as Fig. 3.

experiment with S K.S. Her adjustment sensitivity increased subsequently, but leveled off between the second and third adjustment runs. Typically, a naive S starts with a high threshold criterion, which he then lowers after some experience with the method of adjustments. However, his adjustment thresholds seldom get as low as his FCS thresholds; apparently he adopts a criterion in the range of 90%-100% probability of detection (compared to the 75% imposed by the FCS mode).

Figure 4 shows a similar comparison for another S. S D.K. (one of the authors) is somewhat atypical, having had hundreds of hours of practice in experiments with this particular apparatus. If practice lowers the adjustment threshold, his adjustment sensitivity should be greater than that of S K.S.; and it is, relative to his FCS sensitivity. His adjustment sensitivity may still be slightly less than his FCS sensitivity, but the two are much closer together than they are for our other Ss. Evidently he uses a lower threshold criterion, closer to the FCS level. As in Fig. 3, the FCS curve in Fig. 4 was obtained by averaging data from three sessions, a total of about 3.5 h observing time.

However, the contrast sensitivity curves obtained from individual FCS sessions are also instructive; these are shown for a third S in Fig. 5. Each of the dashed curves in this figure connects the end points of the 12 staircases obtained in a single experimental session (see Fig. 2b). The mean curve for these three FCS sessions is shown for comparison with the previous figures. Figure 5 also shows some systematic variation among three adjustment runs for this S. (S H.P. was more experienced than K.S., but even an experienced S will not always hold the same adjustment criterion from one run to the next.) Again, the FCS sensitivity is about five

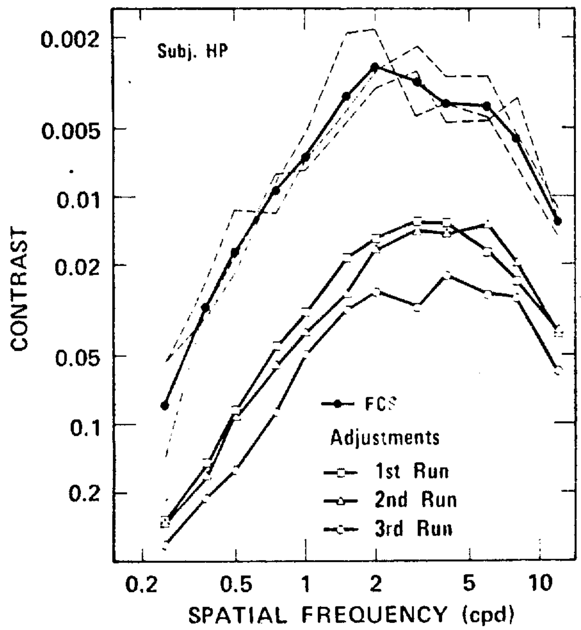

Fig. 5. Contrast sensitivity vs spatial frequency for S H.P. Same conditions as Figs. 3 and 4. Dashed lines show data from three FCS runs, averaged to obtain filled-circle points.

times greater than the adjustment sensitivity.

The most important result shown in Fig. 5 is the *nature* of the variability among FCS runs and among adjustments runs. Although the FCS data are about as variable as the adjustment data, the adjustment variability is mainly systematic, while the variability among the FCS runs seems random. (Note that the FCS curves from individual sessions cross and recross each other and the mean curve several times.) The data were subjected to a chi-square test of the hypothesis that mean rank contrast sensitivity is independent of session number. This hypothesis can be rejected for the adjustments data ($p < .001$), but cannot be rejected for the FCS data ($p = .1$).

Now, if the FCS method eliminates systematic intra-S variability from one run to the next, and if this intersession variability is caused mainly by changes in S's criterion, then we would expect this method to minimize the variability *among Ss* as well. The data shown in Fig. 6 tend to confirm this expectation. Here the mean FCS curve for S H.P. is repeated, together with similar data for two other young, emmetropic Ss. Note the close similarity among all three contrast sensitivity curves, particularly at frequencies below 2 cpd. These data (and others not reported here) all tend to confirm the presence of a low-frequency inhibiting effect with a relatively steep slope (about 2 in log-log coordinates).

DISCUSSION

Instructing S to try to detect *any* perturbation of the uniform field may be important in making the adjustment curves so similar in shape to the FCS curves. One should not assume that our results would be obtained if S were instructed to detect the presence of a grating, or to report its orientation, count its fringes, etc. The use of other subjective criteria can doubtless change the shape of the sine wave threshold curve.

When minimum threshold values are not required, and occasional criterion differences among and within Ss can be tolerated, the method of adjustments is obviously preferable, because it yields equally smooth curves in about a 10th of the time required by the FCS method.[1] However, the FCS method eliminates criterion differences and provides information about S's performance (not just his judgments).

Summarizing our results with five Ss, ranging from naive to quite experienced: (1) Both methods yield the same curve *shape*, but the FCS method gives significantly greater sensitivity than that obtained by the method of adjustments: the increase may be as great as a factor of 5 (depending on S's adjustment criterion). (2) Presumably because it is independent of threshold criteria, the FCS method does not show systematic changes of sensitivity from one run to the next (as the method of adjustments sometimes does.) (3) The variability of the FCS data is mainly random and can therefore be made quite small by taking enough data. (4) When this is done, individual differences (among young, emmetropic Ss) tend to disappear.

These results are essentially what would be expected, based on the differences between the two psychophysical methods. We conclude that, if the S is appropriately instructed, the shape of his sine wave grating sensitivity curve is not affected by using the method of adjustments. Moreover, it seems likely that this negative result would be maintained if the present study were extended to other criterion-dependent

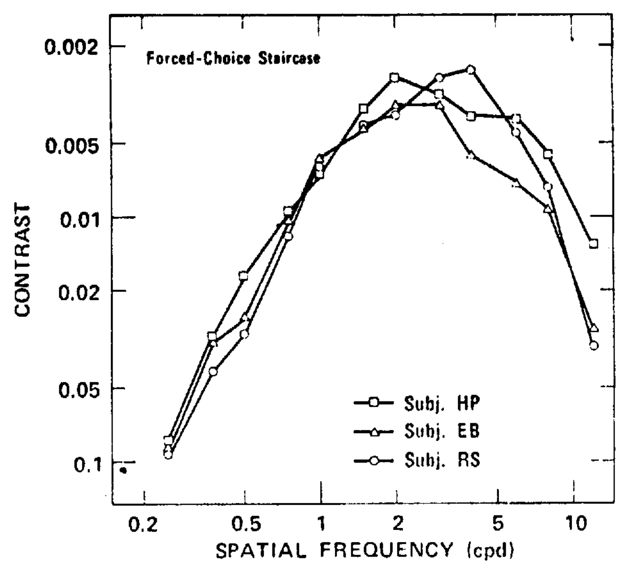

Fig. 6. Contrast sensitivity vs spatial frequency for three young, emmetropic Ss, obtained by the FCS technique.

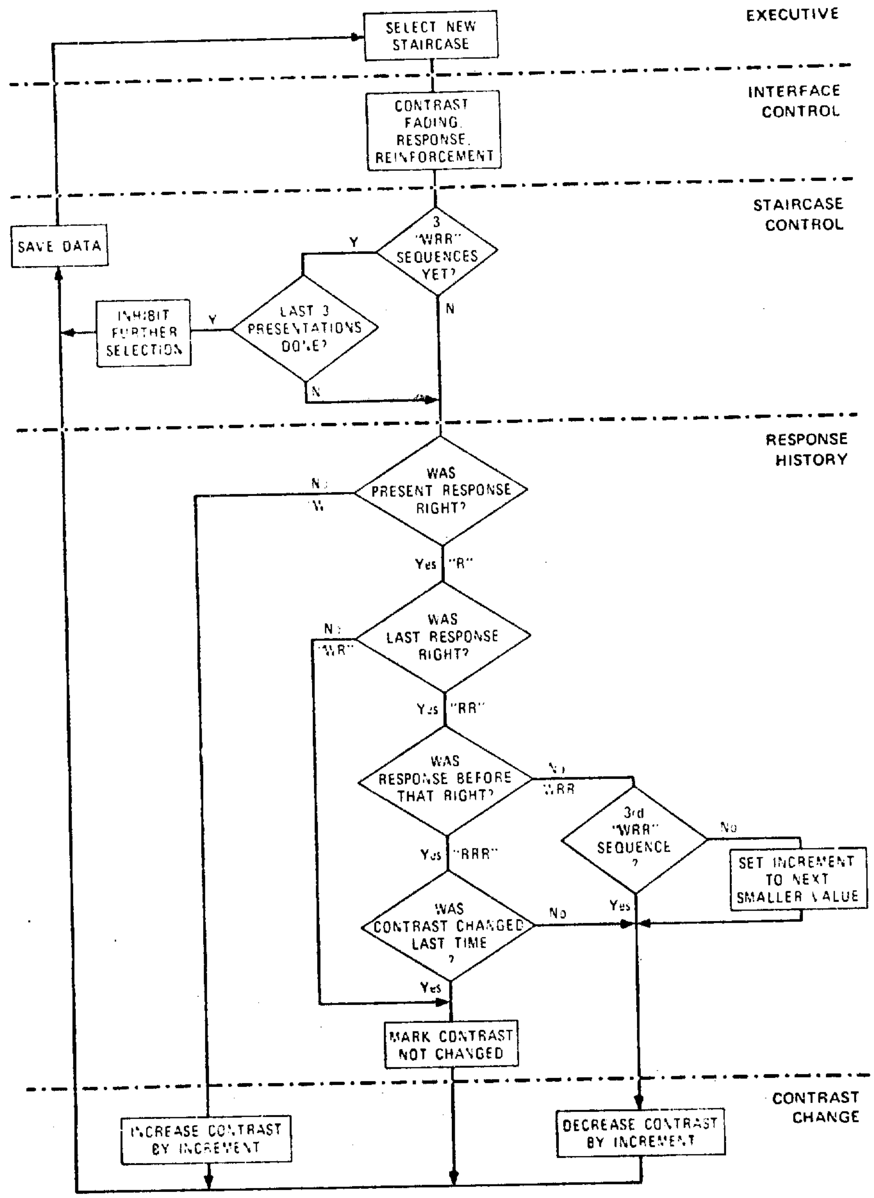

Fig. 7. Flow-chart representation of the FCS computer program.

psychophysical methods in general. Thus, our results tend to support the sine wave threshold data obtained by these methods.

APPENDIX

The Forced-Choice Staircase (FCS) Computer Program

The operation of the FCS computer program can be divided into five functional categories: executive, interface control, staircase control, response history, and contrast change (see Fig. 7).

The executive section of the program initializes the experiment, selects (from a random table) one of the 12 stimulus patterns for presentation at each trial, performs various bookkeeping functions, and calculates and prints out the average data at the end of an experimental session. The staircase control portion of the program operates on a parameter table for the staircase currently selected; it keeps track of the previous three responses, the previous eight contrasts, the present contrast, and contrast increment size (and other parameters for internal use). These historical data are needed for each staircase to determine its subsequent contrasts.

The interface control portion of the program controls the stimulator interface, which operates the entire sequence of each trial: stimulus generation, contrast fading, marker tones, and reinforcement. When S makes a response, the computer reads data from the interface, indicating whether the response was right or wrong (or whether the "pause" switch was set).

The response history section is the heart of the FCS program: Fig. 7 shows a flow chart of this section and its relation to the other parts of the program. Each staircase follows the algorithm according to its own history, independent of the other staircases. The next contrast to be presented (for the selected staircase) is calculated on the basis of the present contrast, the present response, the previous two responses, the contrast increment, and whether the contrast was changed after the previous response. The contrast algorithm is as follows: (1) When S makes a wrong (W) response, the contrast of that pattern is increased for its next presentation. After he makes two successive right (R) responses to the same pattern, its contrast is decreased (this sets the average end point of each staircase at about 75% correct). The new contrast is obtained by multiplying (or dividing) the preceding contrast by a fixed ratio (i.e., a constant log increment). (2) Each time the sequence W,R,R occurs, the size of this increment is decreased. (This is most likely to occur when the contrast increases from below to above the 75% correct level.) The successive increment sizes are: 8X, 2X, 1.3X. (3) After the sequence W,R,R has occurred three times with a given pattern, the staircase terminates with three more trials using the smallest increment, and that pattern is not presented again. The session ends when all staircases have terminated.

The last eight contrasts from each staircase are averaged to obtain the threshold. The minimum number of trials before termination but after the second W,R,R sequence is eight. Therefore, all contrasts being averaged were necessarily presented during the period when the smallest contrast increment was in effect.

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NOTE

1. Because the FCS sessions are long and tiresome, a number of preliminary experiments were conducted to determine the most suitable compromise between speed and end-point stability. We found that the variability shown in Fig. 5 could not be decreased significantly without prohibitive increases in run length. The number and sizes of our increments were governed by the following constraints (see Cornsweet, 1963): (a) For maximum efficiency, the smallest increment must be fixed at about the same size as the contrast-difference threshold for sinusoidal gratings; at a spatial frequency of 2.1 cycles/deg, Kohayakawa (1972) obtained jnds of 30% to 60% with low-contrast gratings. (Note that this is much larger than the jnd of luminance.) (b) All staircases must start at a common baseline; for this purpose, we chose 100% contrast. (To start at equal distances from threshold would require an a priori assumption of the curve shape we are measuring, which could bias the result.) (c) If the contrast is to approach threshold quickly, the initial increment must be much larger than specified in (a). The increment should decrease as the contrast approaches threshold, but not so rapidly as to run a high risk of being "trapped" in a small increment far from threshold. (d) Subject to constraint (c), the total number of increments should be minimized.

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