Phenomenological Research and Analysis

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I. OBJECTIVE

The objective of this document is to provide a technical final report on tasks 6.2, "Basic Research," 6.3, "Applied Research," and 6.4, as listed in the 1991 Statement of Work. This report covers the time period from 4 February 1991 to 30 June 1992, and includes all subtasks.*

* This report constitutes the deliverable DI-MISC-80508 under contract number MDA908-91-C-0037.

II. BACKGROUND

With regard to this final report, anomalous mental phenomena (AMP) can be divided into two broad categories:*

- Anomalous Cognition (AC): A form of information transfer in which all known sensorial stimuli are absent.
- Anomalous Perturbation (AP): A form of interaction with matter in which all known physical mechanisms are absent.

For the purpose of this document, we define research that is primarily directed at understanding the nature of AMP (e.g., signal transmission, neurophysiology, etc.) as *basic*. Research that is primarily directed at improving the quality of output (e.g., analysis techniques, choice of target material, etc.) as *applied*. Basic and applied research domains are broad and are highly interactive and mutually supportive. Understanding the technical details of AC phenomena, for example, will improve its application potential, and likewise, being sensitive to the restrictions of a real-world problem may provide insight into underlying mechanisms.

1. Historical Perspective

Serious government research of AMP began in 1973 when a modest effort began at SRI International in Menlo Park, California, to determine if AMP could be verified and to assess the degree to which AMP could be applied in practical situations.

In fiscal year 1986, SRI International conducted the first coordinated, long-term examination of AC and AP phenomena. This program had three major objectives:

- Provide incontrovertible evidence for the existence of AC and AP.
- Determine the physiological and physical basis for AC and AP.
- Determine the degree to which AC data could be applied in practical situations.

The results and conclusions from this program were as follows:

- The first objective was partially met. An information transfer anomaly (i.e., AC) exists that could not be explained by inappropriate protocols, incorrect analyses, or fraud; however, there was insufficient evidence to conclude if AP existed.
- Significant progress was made in meeting the second objective. For example,
  - (1) The central nervous system (i.e., the brain) of individuals with known AC ability appeared to respond to isolated AC stimuli.

* A definition of terms may be found in the Glossary in Section X on page 71.

(2) Two physical models were constructed. One, called Decision Augmentation Theory, suggests a possible physical transfer mechanism for AC data. The other is a speculative physical model for the type of information that is sensed by AC.

Under the same research program, different physical systems were examined for their susceptibility to putative AP effects. They included single-cell algae, single alpha particles, and electronic devices such as random number generators and piezoelectric strain gauges. However, in these carefully controlled experiments, some with experienced AP subjects, no evidence of AP was observed.

2. Current Program

Beginning in February 1991, the sponsor initiated a comprehensive, 18-month investigation of AMP at Science Applications International Corporation. The primary thrusts of this effort were to:

- Prepare a comprehensive, integrated, 5-year research plan.
- Conduct basic and applied research of AMP.

This final report provides a comprehensive technical review of this program and suggests possible paths of inquiry for the future. Major sections within this report are as follows:

- Primary experiments carried out under this program.
- Theoretical and analytical problems.
- Results from three subcontractors and their final reports.

In the following section, we provide an executive summary of this 18-month effort. The executive summary is designed for the non-technical reader; however, the technical and statistical details can be found in the body of the report, which begins with Section IV on page 11. References to the statement of work are given at the beginning of each section and elsewhere, where appropriate.

III. EXECUTIVE SUMMARY

During the course of this 18-month contract, we conducted five experiments that were designed to address specific issues of applied and basic research of AMP. Additionally, we conducted a variety of other investigations that did not require further experimentation. As an example of the latter, we applied fuzzy set theory to the data from one of the experiments. In this section, we provide a non-technical summary of the five experiments. Details on all tasks may be found in the body of the report.

A well-designed experiment provides valuable information regardless of the particular outcome. In our experimental effort during this contract, three studies produced positive outcomes and two did not. All, however, provided useful guidelines for a follow-on effort.

1. Target Dependencies

1.1 Abstract

The purpose of this experiment was to determine if the quality of AC depends upon an intrinsic target property, which is called the change of *entropy* (i.e., the amount of information contained in visual target material). This was examined for two different target types, photographs and short video clips. A second objective was to determine if the quality of AC depends upon a sender (i.e., a person who is isolated from the receiver but who is focusing upon the target material).

The experimental results indicate that the quality of AC does not require a sender to know about, or to focus his or her attention on, the target. Most importantly, we found a strong correlation between the quality of the AC and the change of entropy in a target: That is, the more information determined by information theory contained in the target, the better the AC. Should this result replicate in other experiments, it may be the first indication of an independent physical variable that is fundamental to AC. If so, this information can be used to vastly improve many other types of AC experiments.

1.2 Approach

Each of five receivers, who had previously demonstrated an AC ability, contributed 40 trials each. All receivers worked alone from their homes and, at a prearranged time, conducted an AC trial for a target that was located no less than 500 km away. The target was either a photograph from the *National Geographic* magazine or a short clip from a video movie. For half of the trials, the experimenter acted as a sender, and for all trials, the receivers were unaware of the target type or if there was a sender. After receiving the responses by facsimile machine, the experimenter mailed each receiver the target as feedback. Standard statistical procedures were use to determine whether there were differences in AC quality among these various conditions.

1.3 Results

Three of the five receivers independently demonstrated significant evidence for AC. AC of photographs was statically significant while AC of videos was not, but the difference between them was not large enough to demonstrate a meaningful preference for the photographs. Using the combined data for all receivers, we found a significant correlation, as measured by a subjective *post hoc* technique, between the change of target entropy (i.e., its information content) and the quality of the response.

We did not observe statistical evidence of AC when the targets were video clips, unlike previous research by Honorton. We speculate that the receivers, who had rarely been exposed to this type of target, were unable to discriminate AC from their internal, non-AC experiences. We expand this point in the body of the report.

1.4 Conclusions

A sender is not an *intrinsic* requirement of AC; however, a sender might contribute to a conducive environment for AC. In addition, it is unknown whether a sender facilitates the reception of specific target elements. We are currently examining this last point with one of our subcontractors.

The total change of target entropy may be fundamental to the functioning of AC. This may shed important light on the question, "What is being sensed by AC?" A number of replications are required, however, before we can be certain.

2. Enhancing Detection of AC of Binary Targets

2.1 Abstract

It is often thought that targets in AC experiments are much too complicated. Frequently they consist of photographs of complex scenes such as a city near a mountain. This complexity makes it difficult to quantitatively analyze the information contained in the target and the response. To eliminate this problem, researchers can use binary targets (e.g., red/black cards, 0/1), which are completely defined and can be analyzed by simple statistics. Earlier experiments have used sophisticated mathematical procedures to enhance the detection of AC of binary targets. The purpose of this experiment was to replicate these earlier experiments.

In this experiment, one individual who had demonstrated an ability to use AC successfully when the targets are single binary bits, continued to show his ability. In this case, however, we applied statistical enhancement techniques from information theory to improve the scoring rate. We need to identify a more robust statistical technique to improve the overall efficiency because the receiver was required to "guess" over 21,000 times to reach 100 definite decisions about the binary targets. Of the 100 decisions, he or she was correct 76 times.

2.2 Approach

Each of three receivers contributed 100 AC trials in a computer-driven, binary AC experiment. One receiver had demonstrated consistent AC ability in similar experiments, whereas the other two receivers were inexperienced in binary target AC. It is beyond the scope of this summary to describe the mathematical technique since it may be found in detail in the body of the report. Simply stated, a sophisticated procedure called sequential analysis was used to provide many redundant responses to a single binary number target (i.e., one or zero). Sequential analysis is particularly sensitive to whether there is a "burst" of AC and can also determine to within statistical limits if no AC is present.

2.3 Results

The experienced receiver again produced significant evidence of AC of binary targets. That receiver's hit rate of 51.6% before the application of sequential analysis was improved to 76% as a result of the analysis. The other two receivers scored at chance expectation.

2.4 Conclusions

We confirmed earlier results that it is possible to enhance detection of AC with binary targets using sequential analysis. A major difficulty, however, is that the receivers had to register a guess (i.e. by pressing a computer mouse button) approximately 200 times for each sequential analysis trial. Thus the technique, while capable of enhancing the detection of AC of binary targets, is particularly inefficient due to excessive time expenditures.

3. AC in Lucid Dreams

3.1 Abstract

Throughout human experience, people have reported various types of AC in dreams, and laboratory experiments in the 1970s confirmed that AC may occur in dreams. A lucid dream is defined as one in which a dreamer becomes aware that she or he is dreaming. Extensive research has confirmed the existence of lucid dreaming, and that it is possible for the dreamer to signal the waking world about his or her knowledge about the dream.

The purpose of this pilot study was to determine if AC could occur during lucid dreaming. We found that AC can occur in lucid dreams. Because the dream-trials did not take place in the laboratory, there was some difficulty in interpreting the results; however, it was clear that lucid dreams do not inhibit AC functioning. Because of the success of this experiment, we will be repeating it in an appropriate sleep laboratory.

3.2 Approach

This experiment was designed as a pilot effort. Seven receivers, three experienced in lucid dreaming and four experienced as AC receivers, participated in the study. The four AC receivers were first trained in lucid dreaming before the AC trials began. During each trial, a target was selected randomly from the established pool of *National Geographic* magazine photographs and doubly sealed in two opaque envelopes. The dreamer/receiver placed the envelope next to the bed and was instructed, when a dream became lucid, to "open" the dream envelope (i.e., not the real envelope) while still dreaming, study its content, and report the experience upon waking. The target was provided as feedback once the data had been presented to the experimenter. Our standard rank-order analysis was performed to determine if AC occurred in the study. Since the trials were conducted in each receiver's own bedroom rather than under laboratory conditions, it was difficult to "induce" a lucid dream on demand. Thus, the total number of trials was small (i.e., 21).

3.3 Results

Our analysis confirmed that robust AC occurred during the study; however, the number trials was insufficient to ascertain whether the lucid dream state improved AC functioning.

3.4 Conclusions

Because the size of the AC effect seen in this study is commensurate with that seen in other AC experiments, we conclude that the lucid dream state, at least, does not hinder AC functioning. In the body of the report we suggest a refined experiment to increase the number of lucid dream trials in order to determine if lucid dreaming might enhance AC.

4. Magnetoencephalograph

4.1 Abstract

In this experiment, we attempted to replicate a study in which we found that slow brain-wave patterns appeared to be affected by an isolated flashing light. We were unable to confirm that result; however, important insights resulted from our effort. We did not attempt to show behavioral evidence of AC while measuring the brain waves. That oversight prevented us from determining if the target system was valid for AC. An analogy might be that it would be a mistake to use only a light stimulus in a study of the brain's response to audio information. In addition, we found *post hoc* that in general the statistical nature of brain waves might have fundamentally prevented us from correctly measuring the instantaneous slow rhythms. We suggest that an appropriate follow-on experiment, which remedies these two oversights, be conducted, because the statistical evidence for AC in other experiments strongly suggests that the central nervous system must be involved at some level.

4.2 Approach

Eight individuals were exposed to approximately 1,000 isolated light flashes while their brain activity was being monitored by a magnetoencephalograph, an instrument that measures the magnetic fields produced by active neurons in the brain. The receivers were chosen to participate in the study based on their successful participation in other AC investigations. We searched for subtle changes in their brain activity by measuring various parameters of their alpha rhythms immediately before and immediately after each light flash. A large alpha rhythm usually indicates that the brain is not particularly attentive to external events, moving the body, or thinking. More traditional central nervous system research has shown that any of these activities can cause a change in the alpha rhythm; therefore, it seems reasonable to expect that if AC is a genuine phenomenon, then it too should induce changes in the alpha rhythm.

To assure that any observed effects were not due to an artifact, an equivalent amount of data (i.e., control data) was collected without any receiver under the magneteoencephalograph.

4.3 Results

The earlier results could not be verified in this experiment. The mathematical analysis, which had been used originally, did not reveal any unexpected changes in the subtle properties of the alpha rhythm. The control data also showed no unexpected results.

We did, however, notice a difficulty in this analysis. Because brain waves are always present, there is substantial activity that is considered to be noise (i.e., activity that is not directly related to reactions to stimuli). Our data contained substantial noise and, unfortunately, our analysis technique was so sensitive to it that any brain response to the isolated flashing lights would not have been observed. Fortunately, we have saved all the raw data from this experiment, so all that is required is to reanalyze the data with improved techniques. We are currently engaged in that task.

4.4 Conclusion

Until this new analysis is complete, we are unable to determine whether the brain responds to isolated stimuli. In the body of the report, we suggest that an improved protocol be implemented as part of the continuing research effort.

5. Enhancing the Detection of AC with Binary Coding

5.1 Abstract

The literature reports many attempts at using various statistical approaches to enhance the detection of AC. In this experiment, we used a standard technique from information theory (i.e., error correction through redundancy coding). We were unable to demonstrate that this particular procedure was successful. As a result of this experiment, we identified a number of improvements that might be applied in new studies. For example, in our study, the statistical technique required special targets, which have not been part of our usual collection. A replication will use a pool of targets that have been successfully used in other experiments. We also learned that our statistical procedure was not sensitive to correct AC responses that happened not to be part of the statistical procedure. We have identified a number of new approaches that correct this problem.

5.2 Approach

Five receivers, who had previously demonstrated AC ability, contributed eight trials each. For each trial, all receivers worked alone from their homes and, at a convenient time, conducted an AC trial for a target that was located no less than 500 km away. The targets, which were photographs from the *National Geographic* magazine, were chosen in accordance with specific design criteria and were available for one week for each trial. To use error correcting coding, we identified a series of questions that pertained to the presence or absence of specified target elements. In this way, a target element, for example *water*, could correspond to a single binary bit in the error correcting code. That is, if *water* were present in the target, the value of one would be assigned to it, otherwise it would be assigned a value of zero. We created ten different sets of five target elements and chose photographs that matched the presence/absence criteria. The presence or absence of particular target elements was dictated by the requirements of the 5-bit binary error correcting code that we used in this study. The principle behind error correcting coding in an AC application is that a receiver could "miss" one of the target elements but still arrive at the correct target. Error correction is a common technique found in the computer industry and in deep space communications. We were adapting its use for AC experiments.

After a receiver had completed an AC trial, the response was sent by facsimile to an experimenter in our laboratory in Menlo Park, CA. By return facsimile, the receiver was sent five questions that required yes/no answers for the presence or absence of the target elements. Upon the receipt of the completed questionnaire, the experimenter sent the photograph back as feedback.

Three separate analyses were performed on these data. We used blind rank-ordering of the target and three decoys for each trial to determine if AC occurred during the experiment. In addition, an independent analyst and the receiver separately answered the appropriate questions for each trial. The analyst's answers were compared with the receiver's answers after applying the error correcting code.

5.3 Results

We were unable to confirm the existence of AC in this experiment using the blind rank-order analysis. While the receivers' answers to the questionnaires tended to be much more accurate than those provided by the independent analyst, no answers were good enough to indicate AC using the error correcting coding.

5.4 Conclusions

As was the case in the target-dependencies experiment, we speculate that the receivers, who had rarely been exposed to the type of targets that were used, were unable to discriminate the AC from their internal, non-AC experiences. We expand this point in the body of the report. In addition, we noticed that the answer to a single question depended upon the correct perception of a single target element (i.e., *water*). This element might not be sensed, but others—not included in the five questions—might be sensed. The method could not take into account these other responses. In the body of the report, we suggest a new experiment that improves the target pool and connects the individual coding bits to classes of elements, rather than single elements.

IV. TARGET DEPENDENCIES

This section comprises the final report for SOW items 6.2.2.1 and 6.2.2.2.

1. Objective

There are two objectives of this pilot study:

(1) Explore the effects of target properties on AC quality.

(2) Determine the degree to which AC quality depends upon a sender.

2. Introduction

The field of parapsychology has been interested in improving the quality of responses to target material since the 1930's, when J. B. Rhine first began systematic laboratory studies of extra sensory perception. Since that time, much of the field's effort has been oriented toward psychological factors that may influence AC. In this section, we review the pertinent literature that categorizes targets that have been used successfully in AC experiments.

At a recent conference, Delanoy reported on a survey of the literature for successful AC experiments.[1] She categorized the target material according to perceptual, psychological, and physical characteristics. Except for trends related to dynamic, multi-sensory targets, she was unable to observe systematic correlations of AC quality with her target categories.

Watt examined the AC-target question from a psychological perspective.[2] She concluded that the best AC targets should be those that are psychologically meaningful, have emotional impact, and contain human interest; those targets that have physical features that stand out from their backgrounds or contain movement, novelty, and incongruity also should be good targets.

The difficulty with both the survey of the experimental literature and the psychologically oriented theoretical approach is that understanding the sources of the variation in AC quality is problematical. Using a vision analogy, energy sources of visual material are easily understood (i.e., photons); yet, the percept of vision is not well understood. Psychological and possibly physiological factors influence what we "see." In AC research, the same difficulty arises. Until we understand what factors influence the AC percept, results of systematic studies of AC are difficult to interpret.

Yet, in a few cases, some progress has been realized. In 1990, Honorton et al. conducted a careful meta-analysis of the experimental Ganzfeld literature.[3] In Ganzfeld experiments, receivers are placed in a state of mild sensory isolation and asked to describe their mental imagery. After each trial, the analysis is performed by the receiver, who is asked to rank order four pre-defined targets, which include the actual target and three decoys; the chance first-place rank hit rate is 0.25. In 355 trials collected from 241 different receivers, Honorton et al. found a hit rate of 0.31 ($z = 3.89$, $p \leq 5 \times 10^{-5}$) for an effect size of 0.141. In addition, he found that AC quality was significantly enhanced when the targets were video clips from popular movies (i.e., dynamic) as opposed to static photographs (i.e., effect sizes of 0.32 and 0.05, respectively). All trials were conducted with a sender.

In a carefully conducted meta-analysis, Honorton and Ferrari report significant hitting in forced-choice, precognition experiments.[4] They analyzed 53 years of experiments conducted by 62 different investigators using a limited set of symbols (Zener cards) as target material. Fifty thousand receivers contributed a total of approximately 2×10^6 individual trials. The overall effect size was 0.020 corresponding to a p-value of 6.3×10^{-25}. Similarly, in an earlier review article, Honorton analyzed 7.5×10^5 forced-choice Zener card trials that were collected from 1934 to 1939 and found a significant overall effect size of 0.016 ± 0.001.[5]

Puthoff and Targ published the results of 39 AC real-time trials where the targets were natural scenes in the San Francisco Bay area.[6] The effect size for the 39 trials was 1.15.

Table 1 summarizes these results for each target type:

Table 1.

Effect Size as a Function of Target Type

Target Type	Trials	Effect Size*
Symbols (Real-Time)	7.5×10^5	0.016 ± 0.001
Symbols (Precognitive)	2.0×10^6	0.020 ± 0.001
Static Photographs	165	0.05 ± 0.08
Dynamic Photographs	190	0.32 ± 0.07
Static Natural Scenes	39	1.15 ± 0.16

*Significance may be computed as z = *Effect Size / Error Shown.*

The effect sizes shown in Table 1 are qualitatively monotonically related to target "complexity;" an appropriate quantitative description for target type is currently unknown. Target "complexity," however, was one of the experimentally observed and theoretically conceived attributes examined by Delanoy and Watt, respectively.

A number of confounds exist in this database for the effect-size measures. For example, in all but the Puthoff and Targ study (where targets were natural scenes), the receivers were unselected. That is, they did not participate in the various experiments on the basis of their known ability as receivers. So, is the large effect size for the Puthoff and Targ study because of the accomplished receivers, the natural-scene targets, or some combination of both? While there are other exceptions, the preponderance of the data was from unselected individuals. In many of the trials, a sender was concentrating on the target material, and as in most perception experiments, psychological factors and boredom contributed to the variance in the effect sizes.

In this pilot experiment, we applied one physical measure to static and dynamic photographs to quantify the relationship between target type and AC quality. By careful selection of target content, we minimized the psychological factors in perception. In addition, we minimized individual differences by conducting many trials with each receiver and by only choosing receivers who had previously demonstrated excellent AC skill.

Because the historical database included trials with and without senders, we explored the effects of a sender on AC quality, as well.

3. Approach

3.1 Target-pool Selection

The static target material for this pilot study was a set of 50 *National Geographic* magazine photographs. This set was divided into 10 sets of five photographs that were determined to be visually dissimilar by a fuzzy set analysis.[7] The dynamic target material was four sets of five 60 to 90 second clips from popular video movies. These clips were selected because they had the following characteristics:

- Were thematically coherent.
- Contained obvious geometric elements (e.g., wings of aircraft).
- Were emotionally neutral in that they did not contain obvious arousing material.

The intent of these selection criteria was to control for cognitive surprise, to provide target elements that are easily sketched, and to control for psychological factors such as perceptual defensiveness.

3.2 Target Preparation

The target variable that was considered in this experiment was the total change of Shannon entropy per unit area, per unit time. We chose this quantity because it was qualitatively related to the "information" contained in the target types shown in Table 1, and because it represented a potential physical variable that is important in the detection of traditional sensory stimuli. In the case of image data, the entropy is defined as:

$$S_k = -\sum_{j=0}^{N_k-1} p_{jk} \log_2(p_{jk}), \equiv 0 \text{ if } p_{jk} = 0,$$

where p_{jk} is the probability of finding image intensity j of color k. In a standard, digitized, true color image, each pixel (i.e., picture element) contains eight binary bits of red, green, and blue intensity, respectively. That is, N_k is 256 (i.e., 2^8) for each k, $k = r, g, b$. The total change of the entropy in differential form is given by:

$$dS_k = |\nabla S_k| \cdot \vec{dr} + \left|\frac{\partial S_k}{\partial t}\right| dt. \tag{1}$$

That is, the total change of Shannon entropy is the change because of spatial variations in the static targets added to the change resulting from frame-to-frame variations in the video targets.

We must specify the spatial and temporal resolution before we can compute the total change of entropy for a real image. Henceforth, we drop the color index, k, and assume that all quantities are computed for each color and summed.

3.2.1 Static Targets

To select the 50 static targets, 100 *National Geographic* magazine photographs were scanned at 100 dots per inch (dpi) for eight bits of information of red, green, and blue intensity. At one centimeter spatial resolution, this scanning density provides 1,550 pixels for each 1-cm^2 macro-pixel to compute the p_j.

For a specified resolution, the target photograph was divided into an integral number of 1-cm^2 macro-pixels excluding a thin border, if necessary. The entropy for the (i,j) macro-pixel was computed as:

$$S_{ij} = -\sum_{j=0}^{N-1} p_j \log_2(p_j),$$

where p_j was computed empirically from the pixels in the (i, j) macro-pixel only. For example, consider the target photograph shown in Figure 1.

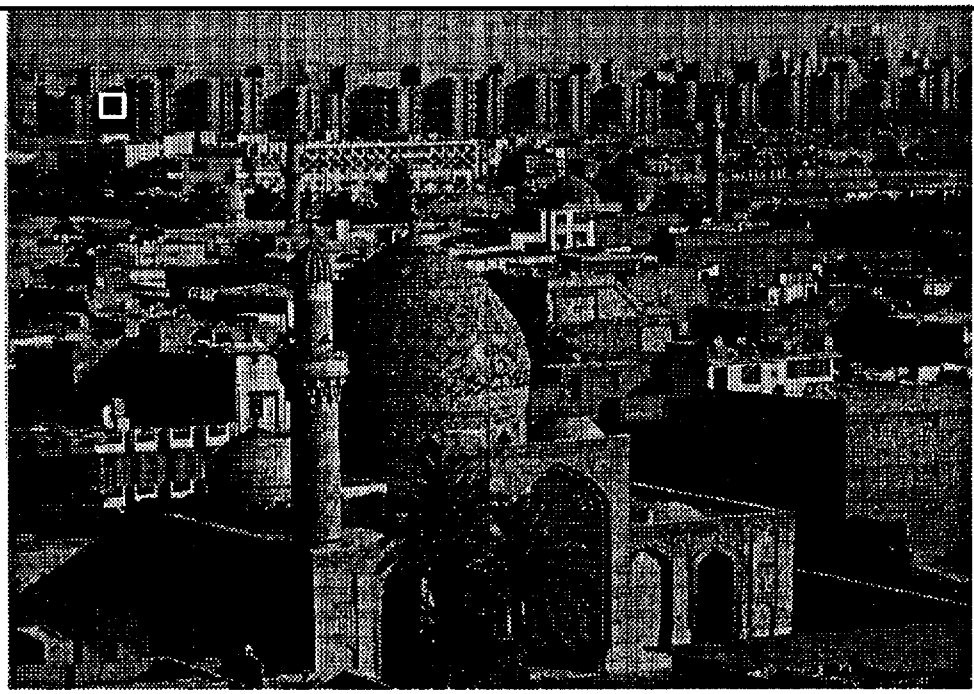

Figure 1. City with a Mosque

Figure 2 shows the probability density for the green intensity for macro-pixel (3,3), which is shown as a white square in the upper left-hand corner of Figure 1.* The probability density indicate that most of the intensity in this patch is near zero value (i.e., no intensity of green in this case). In a similar fashion, S_{ij} is calculated for the entire scene.

* The original photograph was 8.5 × 11 inches, and we have standardized on one centimeter resolution.

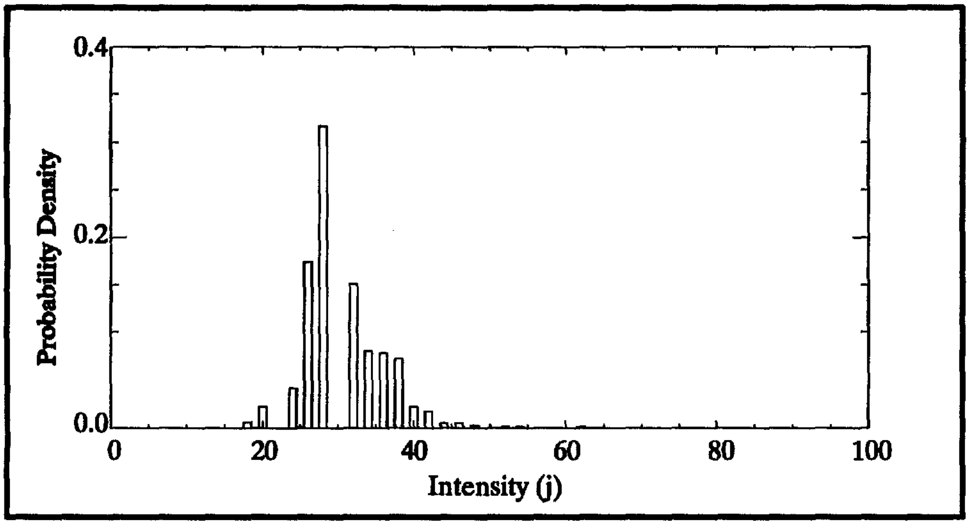

Figure 2. Green Intensity Distribution for the City Target (Macro-pixel 3,3)

We used a standard algorithm to compute the 2-dimensional spatial gradient of the entropy. Figure 3 shows contours of constant change of entropy (calculated from Equation 1) for the city target. The total change per unit area is 1.88 bits/cm.*

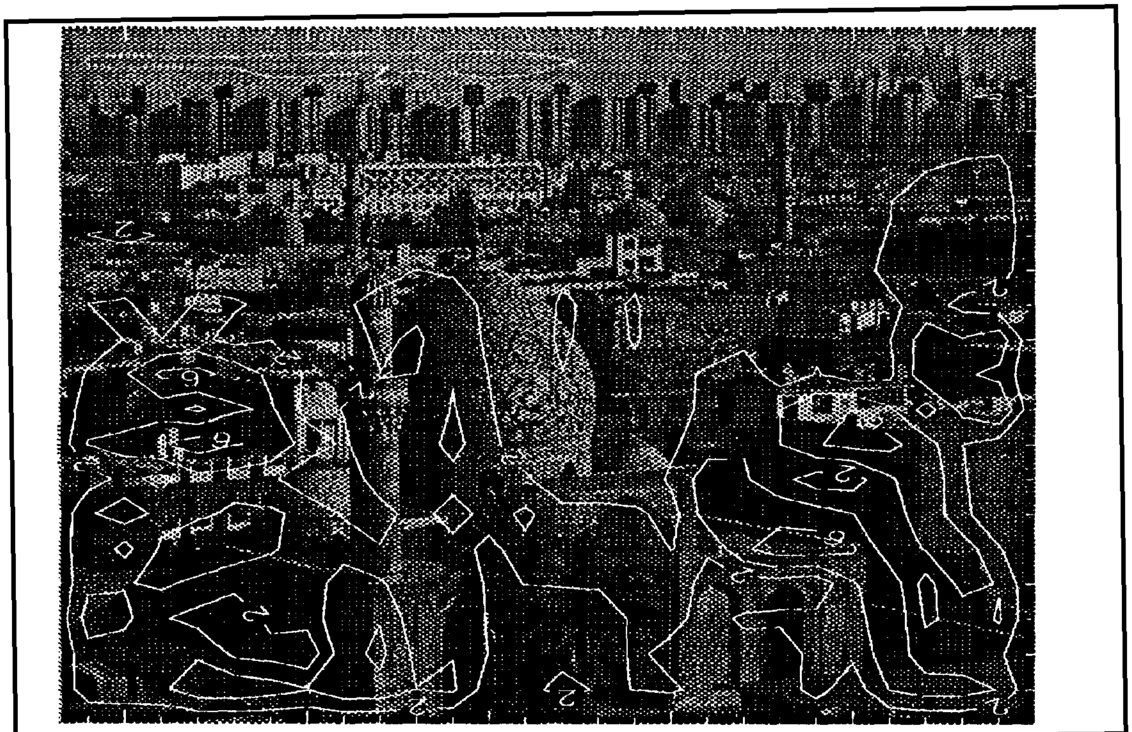

Figure 3. City with Mosque ($|\Delta S|$ = 1.88 bits)

The city target was chosen as an example because it was known (qualitatively) to be a "good" static photograph for AC trials in earlier research. Figure 4 shows contours of constant change of entropy for a photograph that was known not to be a "good" AC target.

* In this formalism, entropy is in units of bits and the maximum entropy is 24 bits.

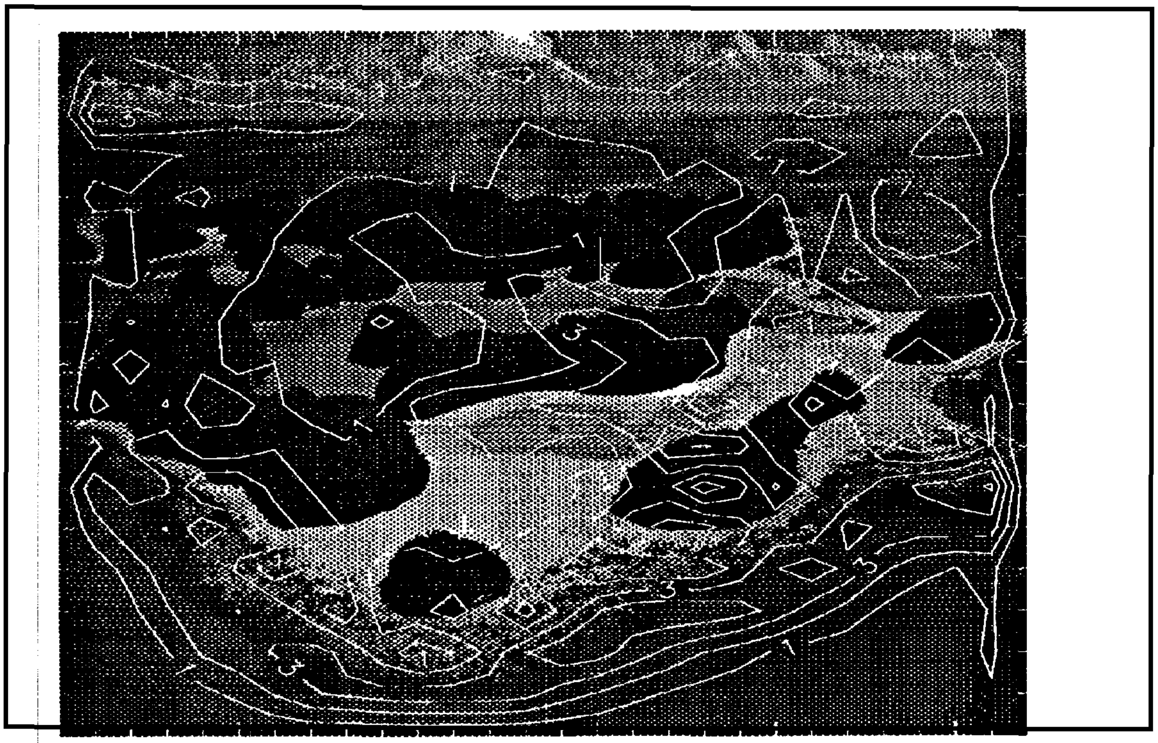

Figure 4. Pacific Islands ($|\Delta S|$ = 1.45 bits)

For comparison, we show in Figure 5 the traditional Zener cards, which were used as targets in most of the forced-choice experiments shown in Table 1.

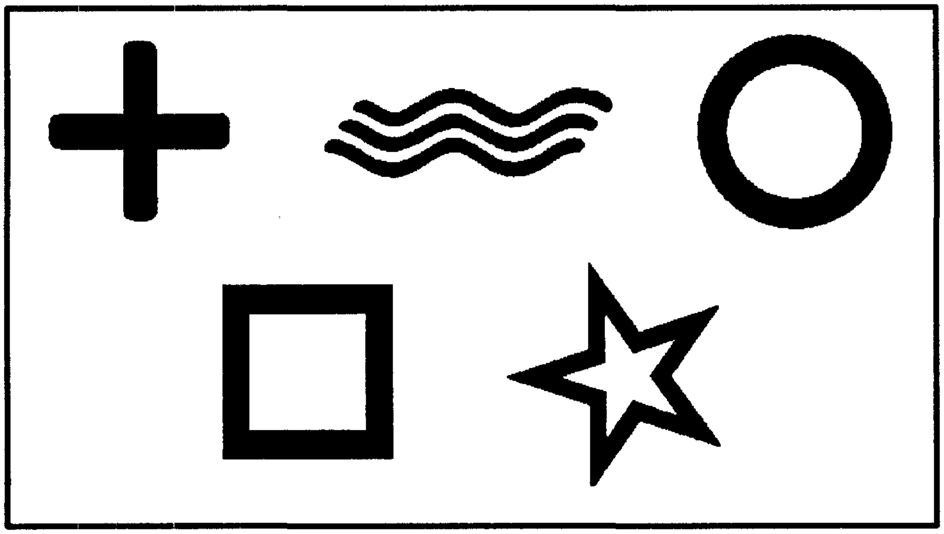

Figure 5. Zener Target Cards (Average $|\Delta S|$ = 0.15 bits)

3.2.2 Dynamic Targets

The total change of entropy for the dynamic targets was calculated in much the same way. The video targets were digitized at approximately one frame per second. The spatial term of Equation 1 was computed exactly as it was for the static targets. The second term was computed from differences between adjacent 1-second frames. Or,

$$\frac{\partial S_{ij}}{\partial t} \approx \frac{\Delta S_{ij}(t)}{\Delta t} = \left| \frac{S_{ij}(t+\Delta t) - S_{ij}(t)}{\Delta t} \right|, \tag{2}$$

where Δt is one over the digitizing frame rate (i.e., one second). We can see immediately that the dynamic targets have a larger ΔS than do the static ones because Equation 2 is zero for all static targets.

3.2.3 Cluster Analysis

Using Equations 1 and 2, we computed ΔS for all the static and dynamic targets. These targets were grouped, using standard cluster analysis, into relatively orthoginal clusters of relatively constant ΔS. Fuzzy set analysis and inspection were used to construct packets of five *visually* dissimilar targets from within each cluster. Our interim report, which is dated 15 February 1992, details the cluster analysis.[8] Figures 6 and 7 show the clusters from that report for the dynamic and static targets, respectively.

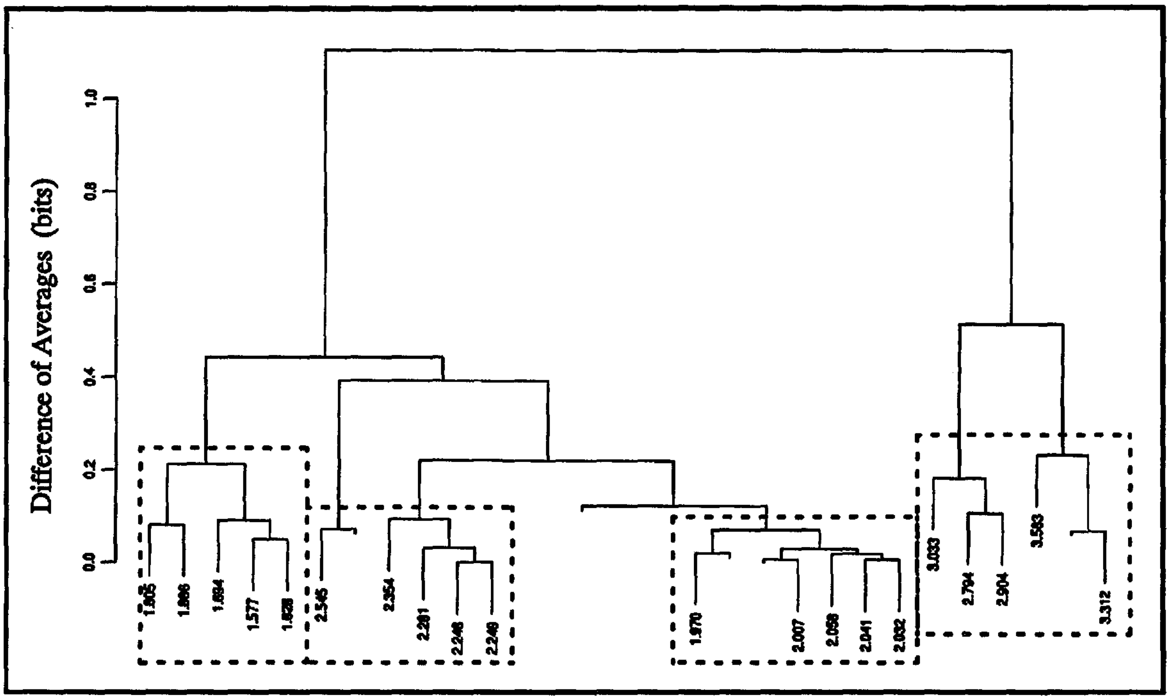

Figure 6. Cluster Diagram for Dynamic Targets

For ease of reading, Figure 7 shows only those 50 static targets that were used to form the constant entropy clusters, rather than the whole set of 100. We show the computed ΔS at the end of each cluster leaf.

3.3 Target Selection

For a specified target type (e.g., static photographs), a target pack was selected randomly and one target of the five within that pack was also chosen randomly.

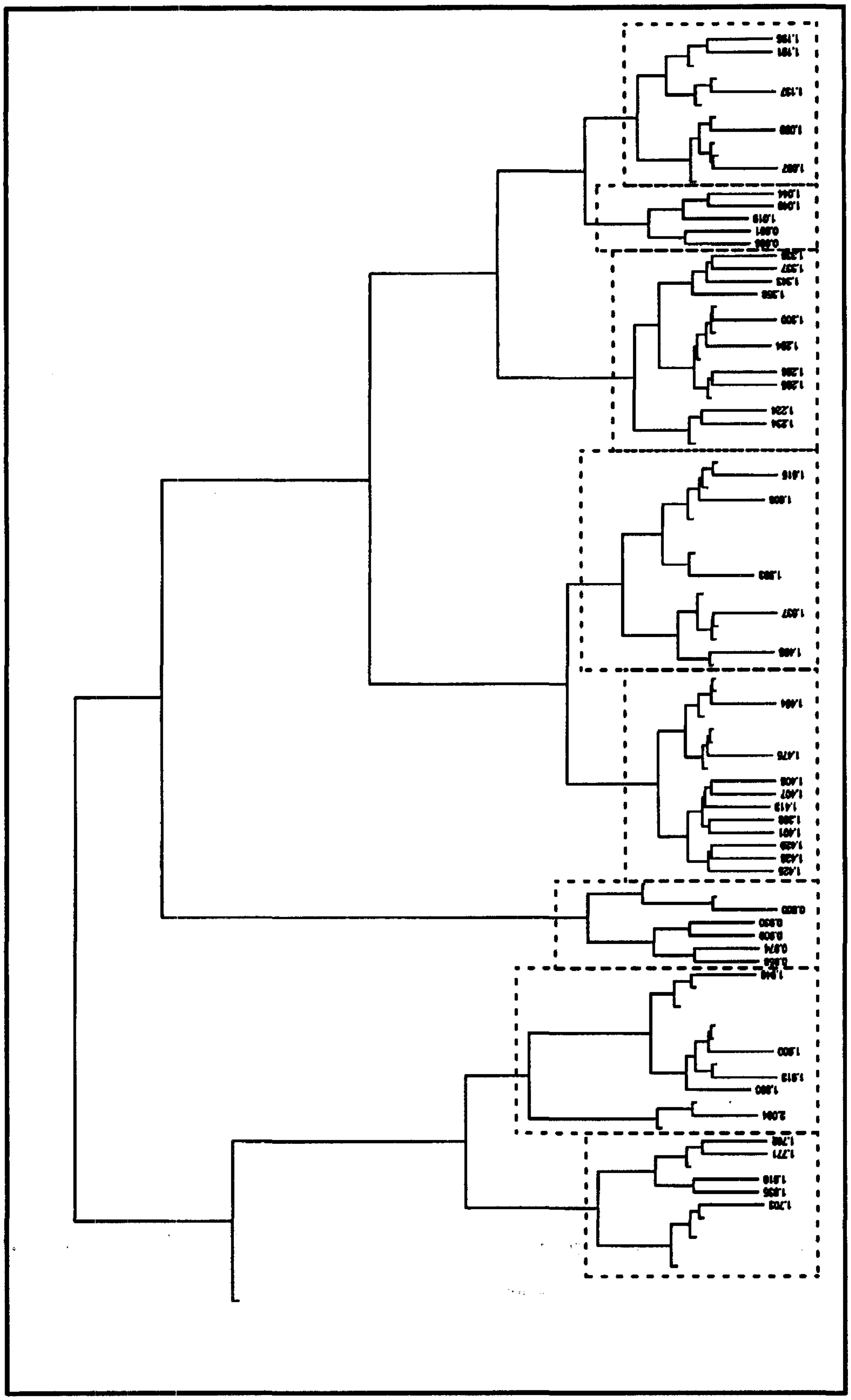

Figure 7. Cluster Diagram for Static Targets

3.4 Receiver Selection

Each of five experienced receivers, who have produced significant AC effect sizes in previous investigations, contributed 40 AC trials (i.e., ten trials under each of the conditions shown in Table 2). Two of the receivers resided in California while the other three resided in Kansas, New York, and Virginia.

Table 2

Experiment Conditions

Condition	Target Type	Sender
1	Static	Yes
2	Static	No
3	Dynamic	Yes
4	Dynamic	No

3.5 Sender Selection

The sender for all trials was the principal investigator (PI), who was in Lititz, Pennsylvania.

3.6 Session Protocol

3.6.1 Target Preparation

Prior to beginning the experiment, an experiment coordinator randomly generated a unique set of 20 static and 20 dynamic targets for each of the five receivers. After a target was selected, it was immediately returned to the pool of possible targets and so could be used again. Within each target type, a counter balanced set of sender/no sender conditions was also generated. A copy of each target was placed in an envelope and a trial number, 1 through 40, was written on the outside. Those envelopes containing targets from the no-sender condition were sealed while those for the sender condition remained unsealed. Each set of 40 targets was packaged separately and shipped to the PI in Pennsylvania.

3.6.2 Trial Schedule

The experiment was conducted over a five month period. Individual schedules were developed with each receiver so as to cause as little inconvenience to their daily routine as possible.

3.6.3 Session Sequence

For each trial and for each receiver, the PI proceeded as follows:

- Selected the appropriately numbered envelope from the box for the appropriate receiver.
- In the sender condition, looked at the selected target for 15 minutes and attempted to "transmit" it to the intended receiver during that time period.
- In the no-sender condition for the static targets, placed the unopened envelope on an uncluttered desk in the PI's office for the 15 minute trial period. In the no-sender condition for the dynamic targets, played the video repeatedly for 15 minutes with the sound turned off and the TV monitor in another room.
- At the conclusion of the 15 minute trial period and after the receipt of the receiver's response by facsimile, sent a copy of the target material (i.e., either a photograph or video tape) to the receiver by mail.

During each trial, the receiver took these actions:

- At the prearranged time, withdrew to a quiet lighted room in his or her home and sat at a desk.
- For a period lasting up to 30 minutes, wrote and drew his or her impressions of the intended target material, which was located in Lititz, PA.
- At the end of the AC trial, sent a copy of the response to the PI by facsimile machine.
- By mail, obtained a copy of the target as feedback for the trial. The target copy and original response were subsequently sent to the experiment coordinator in Menlo Park, CA.

We did not provide specific instructions beyond logistical information to the receivers, because the receivers were all experienced at this type of task.

When the experiment coordinator received the receiver's response, all identifying information (i.e. name, date, and time of trial) was removed from the response. Periodically during the course of the experiment the experiment coordinator provided an analyst, who was blind to the target choice, with a set of responses and associated target packs for analysis. Each target pack consisted of the real target and four decoy targets of the same target type and similar ΔS.

3.7 Analysis

3.7.1 Rank-Order

For each trial, there was a single response and its associated target pack (i.e., either static or dynamic). During the first part of the analysis, a judge, who was blind to the condition and target for the trial, was asked to rank-order the targets within the given pack. This was a forced rank, so regardless of the quality of match between the response and targets within the pack, the judge had to assign a first place match to a response, a second place match to a response, and so on for each of the five targets. The output from this part of the analysis is a rank-order number (i.e., one to five, one corresponding to a first place match) for the correct target. As was described above, the targets within each pack were chosen to be visually different from one another, but they all possessed similar ΔS. Thus, the rank number was not biased because of entropy considerations.

For each receiver, target type, and condition there are 10 such rank-order numbers that constitute a block of data. A rank-order effect size was computed for a block as:

$$\varepsilon_{ij} = \frac{\bar{R}_{ij} - \bar{R}_0}{\sqrt{\frac{N^2-1}{12}}}, \qquad (3)$$

where $\bar{R}_{ij}$ is the average rank for target type i and sender condition j, and $\bar{R}_0$ is the expected average rank, which for this study is equal to three for all cases. In Equation 3, N is the number of possible ranks and is equal to five throughout this study. Reversing the sign in the numerator, Equation 3 reduces to:

$$\varepsilon_{ij} = \frac{3 - \bar{R}_{ij}}{\sqrt{2}}.$$

3.7.2 Analysis of Variance

A two-way analysis of variance (ANOVA) was computed for each receiver. The two primary variables were target type and sender condition (i.e., ANOVA main effects). Each of these variables possessed two states as shown in Table 2.

Possible Effect of Geomagnetic Fluctuations on the Timing of Epileptic Seizures

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Running head: Geomagnetism and epileptic seizure.

Abstract

Some reports have suggested that epileptic seizures might occur more frequently at times of enhanced disturbance of the geomagnetic field. This study examines this putative association using 4101 seizures from 22 epileptic patients where the seizure times were known to within a day or better. A measure of the geomagnetic fluctuation level for the seizure day, and the days preceding the seizures, was derived from the geomagnetic index *ap*. This daily index was significantly higher on the seizure days than on the day prior to the seizures ($p = 0.007$) and slightly higher than for the preceding 10 days ($p = 0.1$). The effect size for the increase for the increase of geomagnetic activity on seizure days from the previous days was inhomogeneous across this group of patients ($p = 0.04$), suggesting an uncontrolled factor. However, a regression of age, sex, seizure type and frequency onto effect size failed to reveal any significant loadings.

Key words: humans; geomagnetism; epilepsy; seizure; magnetic field

Introduction

The reasons for the precise timing of epileptic seizures in most patients remain largely unknown. Statistical studies of seizure timing have failed to identify clearly non-random patterns such as clustering or periodicity in many patients.[1,2] Several explanations for this have been suggested, including the postulation of an inherently random endogenous mechanism[3] and the possibility that seizure occurrence might be more or less tightly coupled to an exogenous variable which itself had nearly random statistics. In considering the second of these hypotheses several workers have looked for a suitable environmental stimulus in the very low frequency region of the electromagnetic (EM) spectrum. EM waves with frequencies of 10^4 Hz or less have several natural sources, including lightning discharges and ionospheric phenomena, and exhibit a complex distribution in time.[4] These long wavelength EM emissions are detectable everywhere on the globe and penetrate buildings and conducting structures with little attenuation. Additionally there is some evidence that such low frequency EM fields can interact with the functioning of biological systems, though the question is far from settled.[5,6] A connection between the triggering of epileptic seizure and low frequency EM radiation therefore has a certain *prima facie* plausibility.

Some reports have suggested that epileptic seizure frequency may be correlated with disturbances of the geomagnetic field (GMF).[7,8,9] Fluctuations in the GMF are primarily driven by changes in the sun's activity and major solar storms give rise to magnetic field changes of up to 1000 nT at the earth's surface and cover a range of frequencies from approximately 20 μHz to 10 Hz.[4] The literature on the effects of magnetic field exposure upon epileptic seizure, while not extensive, contains some suggestive avenues of research. Venkatraman[5] originally suggested that there might be an association between magnetic storms and epileptic attacks but did not provide any statistics to support this conclusion. Rajaram & Mitra[6] reported that monthly averages of admissions of epileptic cases rose during periods of increased GMF variation. However, no attempt was made to control for other factors which influence hospital admissions. According to Keshavan et al[7] a decrease in convulsive threshold in rats was observed during the GMF variation associated with a solar eclipse. Persinger[10] has suggested that increases in the GMF noise level suppress nocturnal melatonin levels, precipitating seizures and consequent cardiovascular instability. Significant correlations have also been reported between epileptic seizure onset and 10 kHz and 28 kHz atmospherics.[11] However a laboratory study of audiogenic seizure susceptible rats failed to find an association between EM at these frequencies and seizure timing.[12] There is also evidence that exposure to relatively intense (10^5 nT) 60 Hz magnetic fields may actually inhibit electrically kindled seizures in rats.[13]

Numerous biological effects from exposure to weak VLF and ULF magnetic fields have been reported, as is demonstrated in reviews of this literature such as those by Adey[5] and Marino and Becker.[6] Interest in the area has recently been stimulated by concern with the possible carcinogenicity of the 50 and 60 Hz magnetic fields associated with power generation and distribution. However, the physical mechanisms which might account for biological sensitivity to weak, low frequency, magnetic fields such as the GMF remain obscure. Adair[14] has calculated the electric fields and other effects in cells and cell membranes consequent upon 60 Hz magnetic fields of larger amplitude (and frequency) than GMF fields. He finds that the induced electric fields are considerably smaller than the fields due to thermal noise. However his arguments do not entirely rule out interactions involving larger multicellular receptors. It is also possible that the putative association between enhanced GMF disturbance and epileptic seizure may not be caused by the magnetic field itself, but rather by some other environmental parameter[15] which co-varies with the GMF changes. The physics of possible mechanisms for electromagnetic triggering of epileptic seizure is not well enough understood to suggest what frequency or amplitude of EM radiation might be responsible for such an effect. While the epidemiological literature suggests that a weak connection between seizure timing and enhanced GMF activity may exist, the evidence is not statistically assessable.

This study examines one of the hypotheses raised by the earlier literature, specifically whether epileptic seizure timing in humans is associated with increased GMF fluctuations at the time of the seizures. Seizure diaries from 22 epileptic patients, containing timings of 4101 seizures, were analyzed to see whether these events occurred at times of enhanced GMF activity. By using seizure diaries, rather than hospital admission records, many potentially confounding factors can be avoided. In the light of the earlier studies it was hypothesized that the days on which epileptic seizures occurred would show higher levels of GMF activity than that of the preceding days.

3.7.3 Post-Hoc Assessment

Rank-order analysis does not usually indicate the absolute quality of the AC. For example, a response which is a near-perfect description of the target receives a rank of one. Yet a response which barely matches the target, may also receive a rank of one. Table 3 shows the rating scale that we used to perform a *post hoc* assessment of the quality of the AC responses regardless of their rank. The quality of an AC response is defined as its visual correspondence with the intended target.

Table 3.

0-7 Point *Post Hoc* Assessment Scale

Score	Description
7	Excellent correspondence, including good analytical detail, with essentially no incorrect information.
6	Good correspondence with good analytical information and relatively little incorrect information.
5	Good correspondence with unambiguous unique matchable elements, but some incorrect information.
4	Good correspondence with several matchable elements intermixed with incorrect information.
3	Mixture of correct and incorrect elements, but enough of the former to indicate receiver has made contact with the target.
2	Some correct elements, but not sufficient to suggest results beyond chance expectation.
1	Very little correspondence.
0	No correspondence.

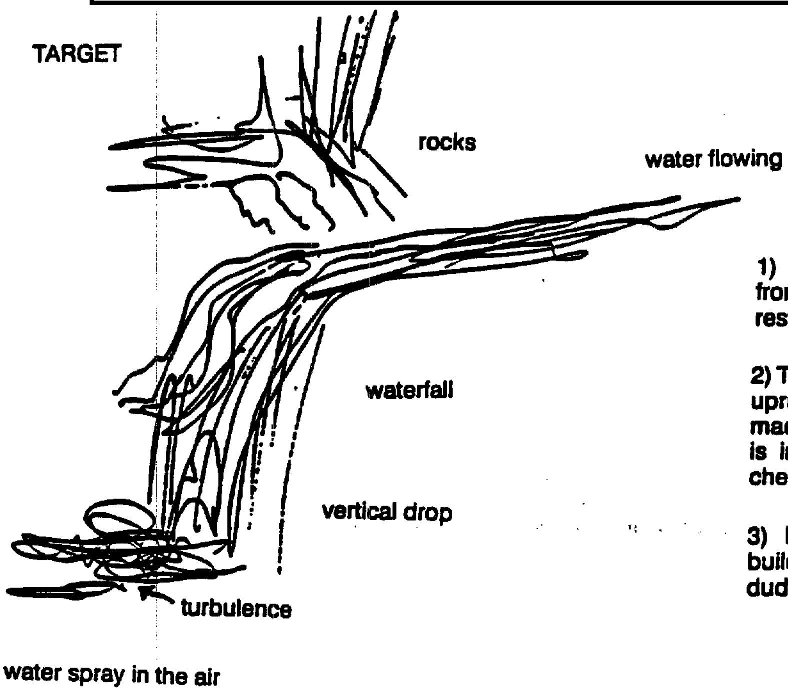
To apply this subjective scale to a target-response trial, an analyst begins with a score of seven and determines if the description for that score is correct. If not, then the analyst tries a score of six and so on. In this way the scale is traversed from seven toward zero until the score-description is correct for the trial.

Figures 8 through 10 illustrate the application of this scale and show that the quality of an AC response is not necessarily indicated by its first-place rank. All three examples were given a rank of one in a blind analysis. These examples were chosen from the experiment which is being described in this section (i.e., Section IV). The response to the waterfall target in Figure 8 included a number of pages of material about a city and other man-made activity. In all of our analyses, we strictly adhere to the concept that any material a receiver deletes from the response prior to feedback is not counted in the analysis. Thus, the response in Figure 8 is considered as complete. The other examples are shown in their entirety.

The scale shown in Table 3 can be divided into two sections, 0-3 and 4-7. The upper portion of the scale indicates clear contact, presumably by AC means, with the intended target material, while the remainder of the scale indicates little or no contact.

We used this scale to provide assessment scores to examine the correlation with the target entropy.

TARGET

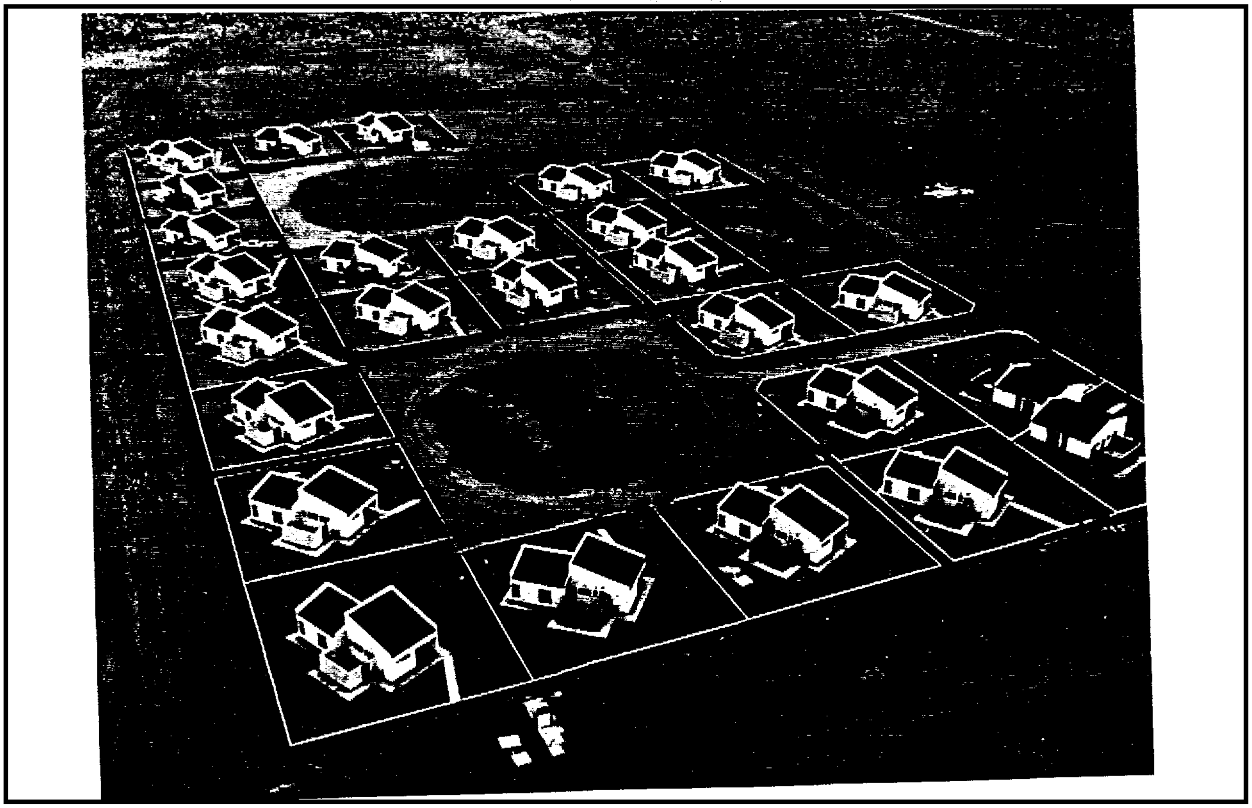


1) City, buildings seems to be a big leap from what I am feeling about the target. I'll restart.

2) Troubled by city feeling. Could be that the uprights are natural rather than man–made. In which case the city interpretation is incorrect and I am feeling MESA. I'll check verticals.

3) DELETE Lights, structure, structures, building, and city. We gots a waterfall, dude.

Figure 8. Target and Response with a *Post Hoc* Rating of 7



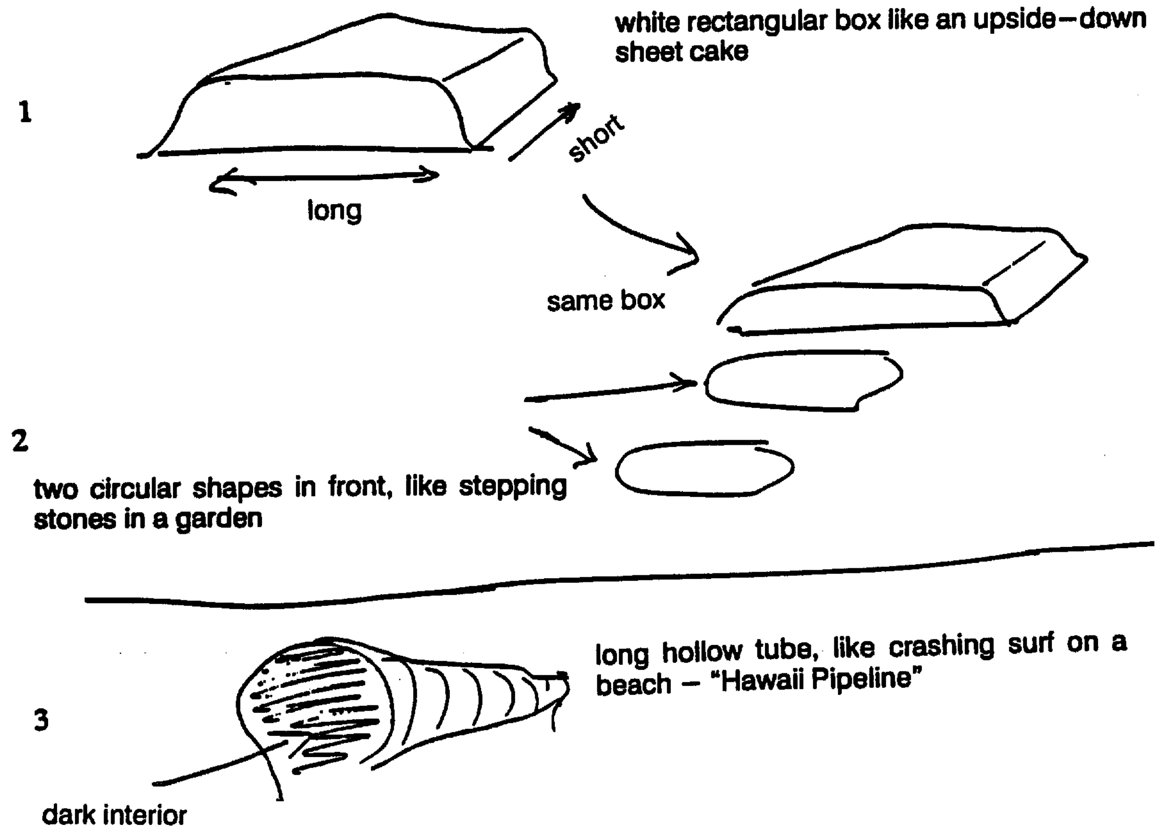
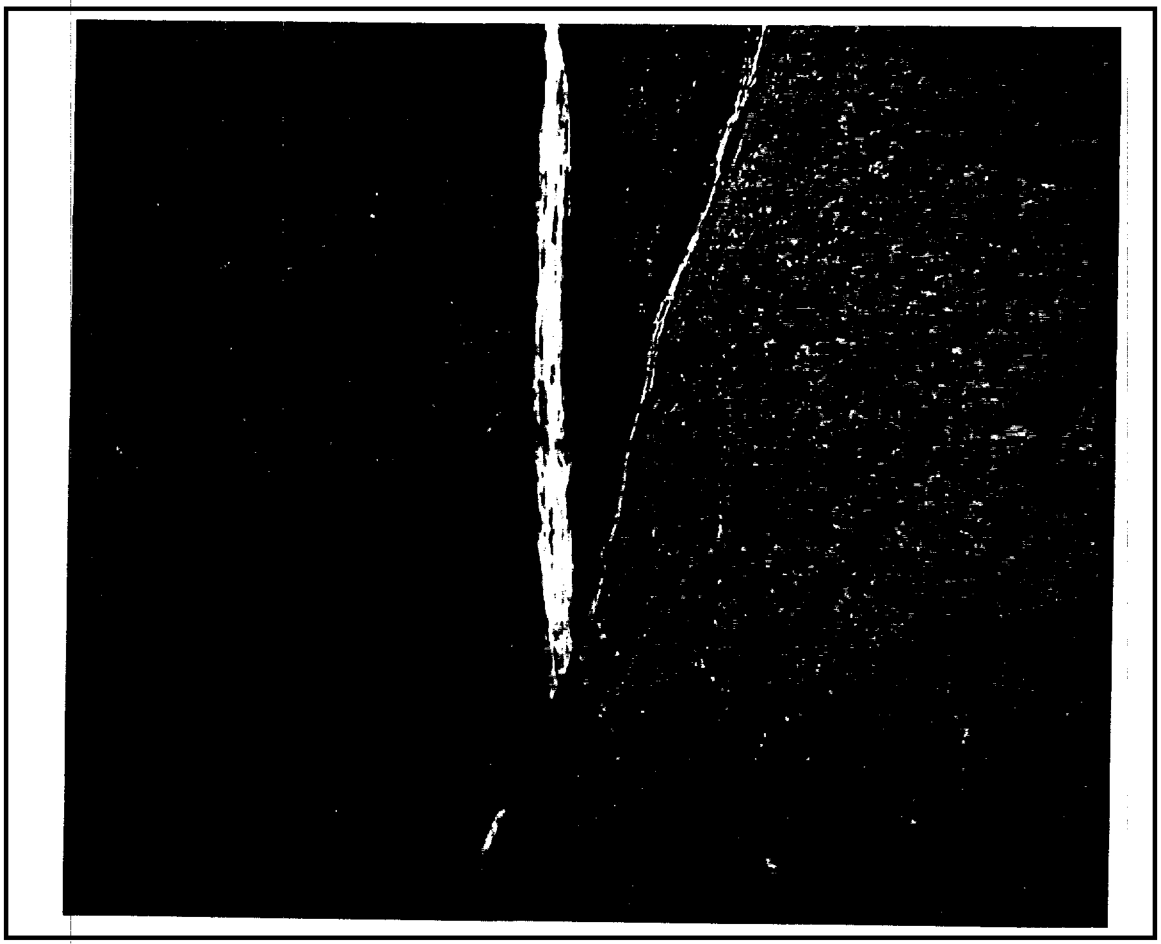
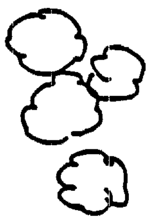


Figure 9. Target and Response with a *Post Hoc* Rating of 4



BEGIN—10:30 AM

puffy balls – almost cotton–like. Cottony puffy splotches. Movement – whizzing through these cottony puffs fast. Dampness. A long walkway & metal girders.



BREAK

I keep wanting to say – specifically – airfield landing strip. Flat land. Big airplanes would land here like naval carriers. Has a broken white line down the center of strip & you see it straight on – like you would be coming in for a landing.

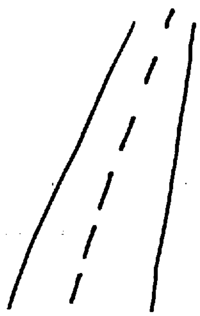


Figure 10. Target and Response with a *Post Hoc* Rating of 1

4. Hypotheses

4.1 Null Hypothesis

The overall null hypothesis was that $\bar{\varepsilon} = 0$.

4.2 Sender and Target Condition

Using an F-test we tested the hypothesis that the quality of AC does not depend upon a sender regardless of target type. Similarly, we used an F-test to test the hypothesis that the quality of AC does not depend upon target type regardless of the sender condition.

The ANOVA also tests for potential interactions between the target and sender conditions. For example, it might be that a sender is required for dynamic targets and not for static ones.

4.3 Target Entropy

The AC quality (i.e., scores greater than three from the *post hoc* scale in Table 3) of each trial was correlated with target ΔS. A significant correlation would indicate that target entropy and AC quality may be linearly related.

5. Results and Discussion

5.1 Effect Size Analysis

Five receivers completed 40 trials each. Table 4 shows the effect sizes (i.e., $z / \sqrt{n}$) computed for the 10 trials in each cell. The shaded cells indicate 1-tailed significant results. Receiver 009 showed significant evidence for AC in the static target, no-sender condition ($p \leq 0.02$); receiver 372 in the static target, sender condition ($p \leq 0.01$); and receiver 518 in the static target, no-sender condition ($p \leq 0.05$). See the underscored values in Table 4.

Table 4.

Effect Sizes

Receiver	Sender Static	No Sender Dynamic	No Sender Static	Sender Dynamic
009	−0.071	0.141	<u>0.636</u>	−0.141
131	−0.071	0.495	−0.071	0.212
372	<u>0.707</u>	−0.283	0.141	−0.354
389	0.141	0.000	0.212	0.000
518	−0.088	0.283	<u>0.530</u>	−0.495

5.2 Analysis of Variance

Table 5 shows the results of an ANOVA on these data. Since there were 10 trials within each cell, the degrees of freedom are the same for all receivers and, therefore, are only shown in the column headings. Two receivers show significant main effects. Receiver 372 showed a tendency to favor static over dynamic targets (i.e., $p \leq 0.03$), and receiver 518 showed a tendency to favor no sender (i.e., $p \leq 0.04$).

See the underscored values in Table 5. That is, for these receivers the ANOVA hypothesis that the data are drawn from the same distribution is rejected. There were no significant interactions between target type and sender condition.

Table 5.

ANOVA Results

Receiver	Sender Condition		Target Type		Interaction	
	F(1,36)	P-Value	F(1,36)	P-Value	F(1,36)	P-Value
009	0.38	0.54	0.68	0.42	2.08	0.16
131	0.18	0.67	1.66	0.21	0.18	0.67
372	1.01	0.32	5.47	0.03	0.61	0.44
389	0.01	0.91	0.33	0.57	0.01	0.91
518	4.43	0.04	0.97	0.33	0.06	0.81

When we combined the data for static targets regardless of the sender condition (i.e., 100 trials), the sum-of-ranks was 265 (i.e., exact sum-of-rank probability of $p \leq 0.0073$, effect size = 0.248). The total sum-of-ranks for the dynamic targets was 300 (i.e., $p \leq 0.500$, effect size = 0.000).

5.3 *Post Hoc* Assessment

Two analysts independently rated all 100 trials (i.e., 20 each from five receivers) from the static-target sessions using the *post hoc* rating scale shown in Table 3. All differences of assignments were resolved in discussion, thus the resulting scores represented a reasonable consensus of the visual quality of the AC for each trial.

We had specified in advance that for the correlation with the change of target entropy, we would only use the section of the *post hoc* rating scale that represented definitive, albeit subjective, AC contact with the target (i.e., scores four through seven). Figure 11 shows a scatter diagram for the *post hoc* rating and the associated ΔS for the 28 trials with static targets that met this requirement. Shown also is a linear least-squares fit to the data and the linear correlation coefficient correlation (i.e., $r = 0.461$, $df = 26$).

This strong correlation suggests that ΔS is an intrinsic property of a static target and that the quality of an AC response will be enhanced for targets with large ΔS. This correlation, however, might be a result of ΔS and the *post hoc* rating independently correlating with the targets' visual complexity. For example, an analyst is able to find more matching elements (i.e., a higher *post hoc* rating) in a visually complex target than in a visually simple one. Similarly, ΔS may be larger for more complex targets. If these hypotheses were true, the correlation shown in Figure 11 would not necessarily support the hypothesis that ΔS is an important intrinsic target property for successful AC.

To check the validity of the correlation, we used a definition of visual complexity that was derived from a fuzzy set representation of the target pool.[7] We had previously coded by consensus 131 different potential target elements for their visual impact on each of the targets in the pool. It is beyond the scope of this report to provide the details of this technique since the details may be found in reference 7. It suffices to say, however, that the sigma-count (i.e., the sum of the membership values over all 131 visual elements) for each target is proportional to its visual complexity. A list of these target elements may be found in Appendix A.

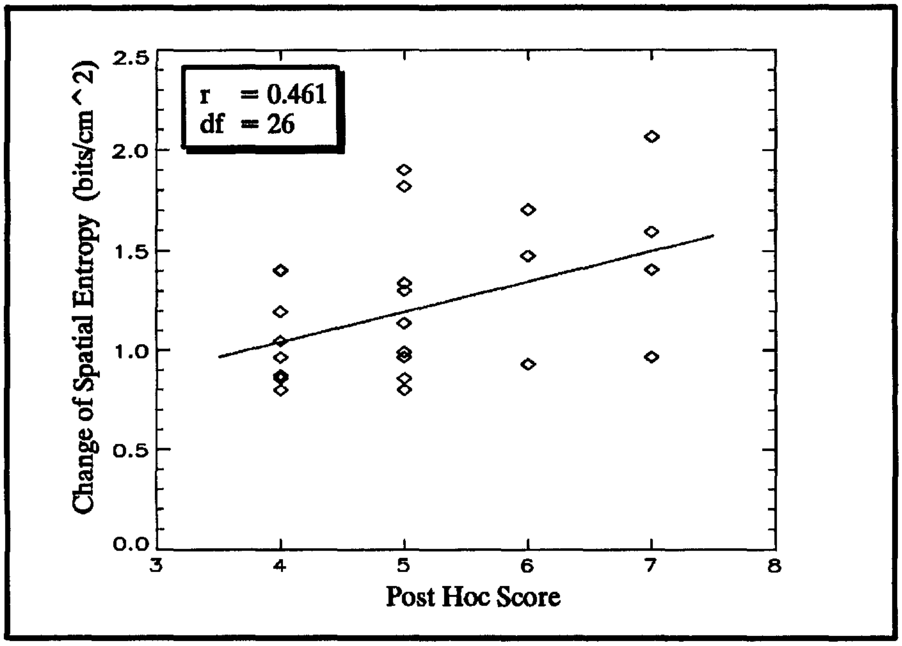


Figure 11. Correlation of *Post Hoc* Score with Static Target ΔS

We computed the liner correlation coefficient for target complexity with the assigned *post hoc* rating. For all 100 static targets used in this study we found $r = 0.049$, $df = 98$, and for target complexity with the measured ΔS, we found $r = -0.031$, $df = 98$.*

On closer inspection neither of these small correlations is surprising. While it is true that an analyst will find more matchable elements in a complex target, so also are there many elements that do not match. Since the rating scale (i.e., Table 3) is sensitive to correct and incorrect elements, the analyst is not biased by visual complexity.

The change of Shannon entropy is derived from the intensities of the three primary colors (i.e., Equation 1 on page 13) and is unrelated to large-scale objects or meaning, which is inherent in the definition of visual complexity. Thus, we would not expect a correlation between ΔS and visual complexity.

Visual complexity, therefore, cannot account for the correlation shown in Figure 11; thus, we are able to conclude that the quality of an AC response depends upon the spatial information (i.e., change of Shannon entropy) in a static target.

A single analyst scored the 100 responses from the dynamic targets using the *post hoc* scale in Table 3. Figure 12 shows the scatter diagram for the *post hoc* scores and the associated ΔS for the 24 trials with a score greater than three for the dynamic targets. We found a linear correlation of $r = 0.043$, $df = 22$.

* Using just the 28 data points in Figure 11, we find $r = -0.216$, $df = 26$ and $r = 0.003$, $df = 26$ for the correlation with the *post hoc* score and ΔS, respectively. Since these correlations are negative or very small, they do not alter the conclusion.

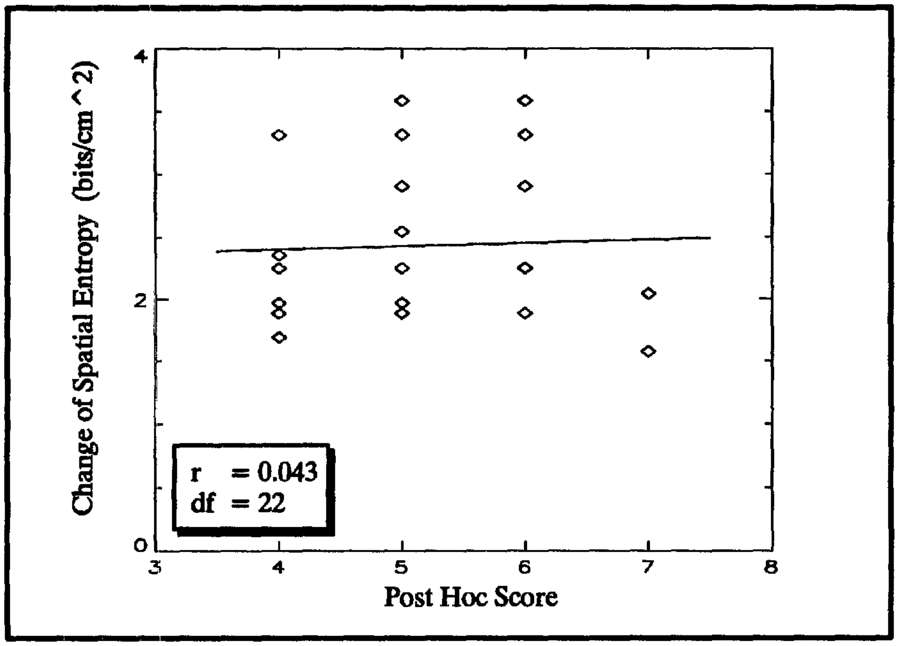


Figure 12. Correlation of *Post Hoc* Score with Dynamic Target ΔS.

This small correlation is not consistent with the result derived from the static targets; therefore, we will examine this case carefully. The total sum of ranks for the dynamic-target case was exactly mean chance expectation, which may indicate that little AC was observed (see Section 5.2, above). Twenty−four trials, however, received a *post hoc* score of four or more. We see in Figure 12 that only two trials received a score of seven, and those trials were among the lowest ΔS. It may be that the small correlation is strongly influenced by these two data points, and a more accurate determination of a putative effect with dynamic targets requires more trials in a future experiment. To determine if there is a trend without the two data points with a score of seven, we computed the correlation for the remainder of the data (i.e., $r = 0.293$, $df = 20$). Given the *post hoc* nature of this calculation, all we can conclude is that we should conduct a similar experiment with dynamic targets to determine if a fundamental correlation between ΔS and AC quality exists, as it does with the static targets.

There is a potentially more important reason that robust AC was not observed in the dynamic target set. Most previous research has considered AC from a "systems" perspective in that the target and receiver are thought of as a single AC unit.[1,2] This is not particularly productive if we are searching for intrinsic properties of target systems to guide target selection. An intrinsic target property is one that is inherently tied to the target (e.g., size, distance from the receiver, activity, entropy) and devoid of any external interpretation. Interpretations, such as emotional impact, can be considered as extrinsic properties of the target or, more precisely, intrinsic properties of the receiver. Extrinsic target properties are critical when AC is viewed from a systems point of view; however, if these properties can be controlled in experiments, then it is possible to examine intrinsic target properties with little confounding interference from the extrinsic ones.

As an aid in understanding extrinsic noise properties of targets, we define target pool *bandwidth* as a qualitative indicator of the number of disparate target elements in the pool. The dynamic targets, which were clips from video movies, represent a large-bandwidth pool; such disparate scenarios as Superman in space, a nature segment on the Grand Canyon, and a James Bond thriller can be included in the same target pool. Conversely, the well-known Zener cards represent a vary narrow target bandwidth. The static targets, which are constructed from a collection of *National Geographic* magazine photographs, represent an intermediate bandwidth; the size and general content of the material is roughly the same throughout the pool.

We hypothesize that the bandwidth of the target pool is a source of *intrinsic* noise in the receiver. We assume that the information that is gained by AC is small compared to other sensory mechanisms, and the primary mental task for a receiver is to discriminate the AC data from internally generated, target-unrelated information. For large bandwidth target pools that may contain almost anything, a receiver is unable to censor his/her internal experience. Thus, target-related and target-unrelated material are equally reported; therefore, large bandwidth pools are extrinsically noisy. Small bandwidth pools are also extrinsically noisy but for a different reason. If a receiver is cognizant of all of a limited set of target elements (e.g., Zener cards), then he/she has an internal discrimination problem. All target possibilities are experienced with equal intensity because of knowledge about the pool and vivid short-term memory. Assuming there is weak AC information about the specific target, then target-extrinsic noise is generated because of the very low signal-to-noise ratio.

Most of our receivers have participated in many earlier experiments which used the static target pool, and were unfamiliar with target pools with large bandwidths such as the dynamic pool. Historically, we have observed AC effect sizes for static targets 50% to 100% larger than we found in this experiment. The current protocol did not include monitoring the AC trials, and the receivers were blind to the target type. It is impossible to determine from this experiment which factor was predominant, but if the bandwidth argument is correct, we would expect a decrease in functioning for even the static targets because receivers would not be able to self-censor their responses.*

We recommend that a new target pool be developed that limits the bandwidth of the dynamic targets and that the static targets be specific frames from within the dynamic target pool. In this way, we can control for target bandwidth effects between the target types. We recommend that a new experiment be conducted with these new target pools.

5.4 Overall Conclusions

Based upon the results of this pilot experiment, we provide the following tentative conclusions:

- The ANOVA results suggest that a sender is not fundamentally required for AC.
- Subject to the caveat suggested in the previous section, the ANOVA results suggest that AC quality does not depend upon target type.
- AC quality for static targets is proportional to a target's spatial information (i.e., ΔS).

Because of the importance of determining if ΔS is an intrinsic target property for all AC targets, we urge that this study be repeated with the improvements discussed above.

* It is important to recognize that limited, or even complete, knowledge of the target pool cannot bias the blind rank-order statistic because it is a differential measure within the pool. It may, however, change the mean of the *post hoc* scores, but correlations are insensitive to means. Thus, correlations based upon the *post hoc* assessment remain valid.

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V. ENHANCING DETECTION OF AC OF BINARY TARGETS

This section constitutes the final report for SOW item 6.2.3.3.

1. Objective

The objective of this investigation was to replicate and extend an earlier study that enhanced the detection of AC of binary targets.

2. Background

In 1984, Puthoff used a majority vote procedure to statistically enhance the detection AC of binary targets.[9] The chance probability of guessing a binary target correctly is 0.50. In Puthoff's experiment, his best receiver, using AC methods, increased the probability to 60%. Using a majority vote of five guesses per bit, the probability of guessing the target correctly was increased by 18.3% from 60 to 71 percent.

In fact, if the probability of guessing a binary target is given by

$$p = p_0 + \delta, \tag{4}$$

where δ is a non-negative constant much, much less than unity and $p_0 = 0.5$, then it can be shown that a majority vote procedure is the most efficient method for obtaining an arbitrarily accurate guess. Let n be the number of bits in a majority vote procedure (i.e., n is assumed to be odd). Then the majority vote probability is given by a binomial sum as:

$$P(n) = p^n + \binom{n}{n-1} p^{n-1}(1-p) + \cdots + \binom{n}{\frac{n+1}{2}} p^{\frac{n+1}{2}}(1-p)^{\frac{n-1}{2}},$$

where p is the single bit probability given by Equation 4. By choosing n large, $P(n)$ can approach unity.

The problem is that a majority vote procedure is predicated on the assumption that ε is not a function of time, an assumption that is known not to be true in AC experiments. Ryzl attempted to solve this problem by modifying a majority vote scheme to include on-line checks.[10] He was able to demonstrate a 100% accurate guess of 15 decimal digits encoded as 50 binary digits ($p = 10^{-15}$).

In 1985, Puthoff, May, and Thomson used a well-known technique called sequential analysis (SA) and, for one receiver, realized a 3.7% enhancement 53.6 to 55.6 percent in a binary AC experiment.[11] Differing from the usual statistical analysis, SA does not require that the sample size be specified in advance; however, by adjusting certain SA parameters, it is possible to set the expected number of trials in the processes.

In this pilot experiment, we set the expected number of trials in an SA algorithm to match the temporal variation of $\delta(t)$. Thus, we expected to realize a significant enhancement of binary AC.

3. Approach

3.1 Theoretical

Let p be the probability that a binary random variable has the value one. With SA, we test the hypothesis H_0: $p = p_0$ against the hypothesis H_1: $p = p_1$. After accepting H_0 as true, define α to be the probability that H_0 was false and that H_1 was true (i.e., Type I error). Likewise, after accepting H_1 as true, define β to be the probability that H_1 was false and that H_0 was true (i.e., Type II error). Let n be the current sample number. With parameters p_0, p_1, α, and β, SA defines two lines as follows:

$$y_1 = a\,n + b_1 \quad \text{and} \quad y_0 = a\,n - b_0, \text{ where}$$

$$a = \frac{\ln\left(\frac{1-p_0}{1-p_1}\right)}{\Delta}, \quad b_0 = \frac{\ln\left(\frac{\beta}{1-\alpha}\right)}{\Delta}, \text{ and } b_1 = \frac{\ln\left(\frac{1-\beta}{\alpha}\right)}{\Delta}, \text{ where} \qquad (5)$$

$$\Delta = \ln\left(\frac{p_1}{p_0}\right) + \ln\left(\frac{1-p_0}{1-p_1}\right).$$

Let N be the accumulated number of ones in a Bernoulli sampling situation. Then the general SA decision algorithm is as follows:

- Collect one binary sample and add its value (i.e., zero or one) to the accumulated number of ones, N.
- Compare the accumulated value to y_1 and y_0 in Equation 5.
- If $N \geq y_1(n)$, then stop the sampling and conclude that hypothesis H_1 is true with a risk of being wrong of β.
- If $N \leq y_0(n)$, then stop the sampling and conclude that hypothesis H_0 is true with a risk of being wrong of α.
- If $y_0(n) \leq N \leq y_1(n)$, then continuing sampling.

In the general theory of SA, this decision process always converges, and the expected number of samples for a decision in favor of each hypothesis is given by:

$$E_{H_0}(n) = \frac{(1-\alpha)\ln\left(\frac{\beta}{1-\alpha}\right) + \alpha\ln\left(\frac{1-\beta}{\alpha}\right)}{p_0\ln\left(\frac{p_1}{p_0}\right) - (1-p_0)\ln\left(\frac{1-p_0}{1-p_1}\right)}, \text{ and}$$

$$E_{H_1}(n) = \frac{\beta\ln\left(\frac{\beta}{1-\alpha}\right) + (1-\beta)\ln\left(\frac{1-\beta}{\alpha}\right)}{p_1\ln\left(\frac{p_1}{p_0}\right) - (1-p_1)\ln\left(\frac{1-p_0}{1-p_1}\right)}. \qquad (6)$$

For an arbitrary value of p, we compute the probability that the SA algorithm will decide in favor of hypothesis H_1 (i.e., the operating characteristic function—OC) as:

$$OC(p) = 1 - \frac{\left(\frac{1-\beta}{\alpha}\right)^h - 1}{\left(\frac{1-\beta}{\alpha}\right)^h - \left(\frac{\beta}{1-\alpha}\right)^h}\text{, where } p \text{ is given by}$$

$$p(h) = \frac{1 - \left(\frac{1-p_1}{1-p_0}\right)^h}{\left(\frac{p_1}{p_0}\right)^h - \left(\frac{1-p_0}{1-p_1}\right)^h}\text{, where } -\infty \le h \le +\infty. \qquad (7)$$

3.2 A Two-tailed Example of Sequential Analysis

In this section we modify the formalism of SA to include a measure of the difference between the accumulated number of ones and the expected number of ones. This will allow a two-tailed application of SA. The only modification that is necessary to Equation 5 is that the slope, a, is now given by:

$$a = \frac{\ln\left(\frac{1-p_0}{1-p_1}\right)}{\Delta} - p_0. \qquad (8)$$

In this example we assume that $\alpha = \beta$, so that the curves (see Figure 13) that define the decision algorithm are symmetric. Let δ be the accumulated excess number of ones (i.e., the number of ones minus the expected number of ones). In the two-tailed case, the two hypotheses that are tested by SA become $H_0: p = p_0$, and $H_1: p = p_1$ or $p = 1 - p_1$.

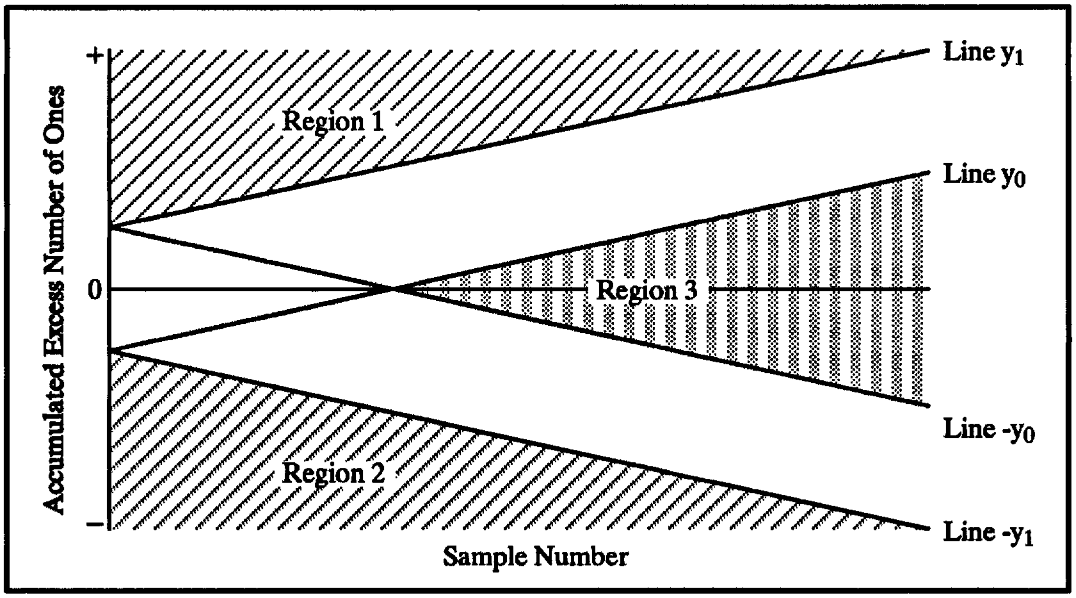


Figure 13. Two-tailed SA Decision Graph

When δ enters either Region 1 or 2, stop the sampling and assume H_1 is true with a Type II error of β. Likewise, if δ enters Region 3, stop the sampling and assume H_0 is true with a Type I error of α.

3.3 Hypotheses

The two hypotheses that were tested in this experiment are:

(1) $H_0: p = p_0 = 0.5$, and

(2) $H_1 : p = p_1 = 0.6$ or $p = 1 - p_1 = 0.4$.

We chose $P_0 = 0.5$ because that is the expected hit rate for binary guessing, and we chose $p_1 = 0.6$ because that was the approximate individual hit rate reported in Ryzl's and in Puthoff's experiment. We adjusted the values of α and β such that the expected number of samples per SA decision was approximately 40, a value that is consistent with anecdotal reports of how many trials can be collected during a single session before a receiver becomes bored with the task. Figure 14 shows the OC curve for these parameters.

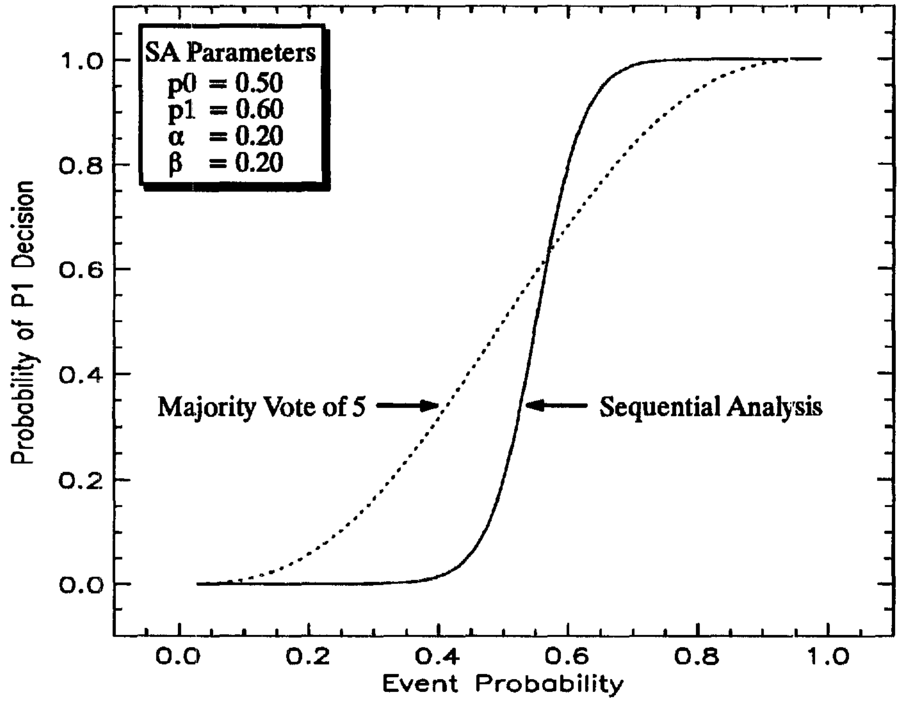


Figure 14. Operating Characteristic Function — 1-Tail

For comparison, we also show in Figure 14 the majority-vote-of-five curve that was successfully employed in Puthoff's experiment. Using the SA method, we expect an enhancement of approximately 42% at 0.6 hitting rate compared to the 18% seen by Puthoff. In addition, our two-tailed formalism allows a receiver to use AC to detect either a binary one or a binary zero. Another advantage of SA over majority vote can be see from Figure 14. For p less than 0.5, the Type I error is sharply reduced. Thus, the false-positive decisions are reduced accordingly.

Figure 15 shows the OC for the 2-tailed SA scheme displayed in Figure 13. For this calculation, we assume that the accumulated deviations result in an extreme decision (i.e., lines $\pm y_1$). That is, under the null hypothesis, 80% of the decisions will be on the inner decision lines in Figure 13. Of the 20% remaining decisions, 50% will strike the upper decision line. This curve, therefore, demonstrates that under the null hypothesis there will be no enhancement.

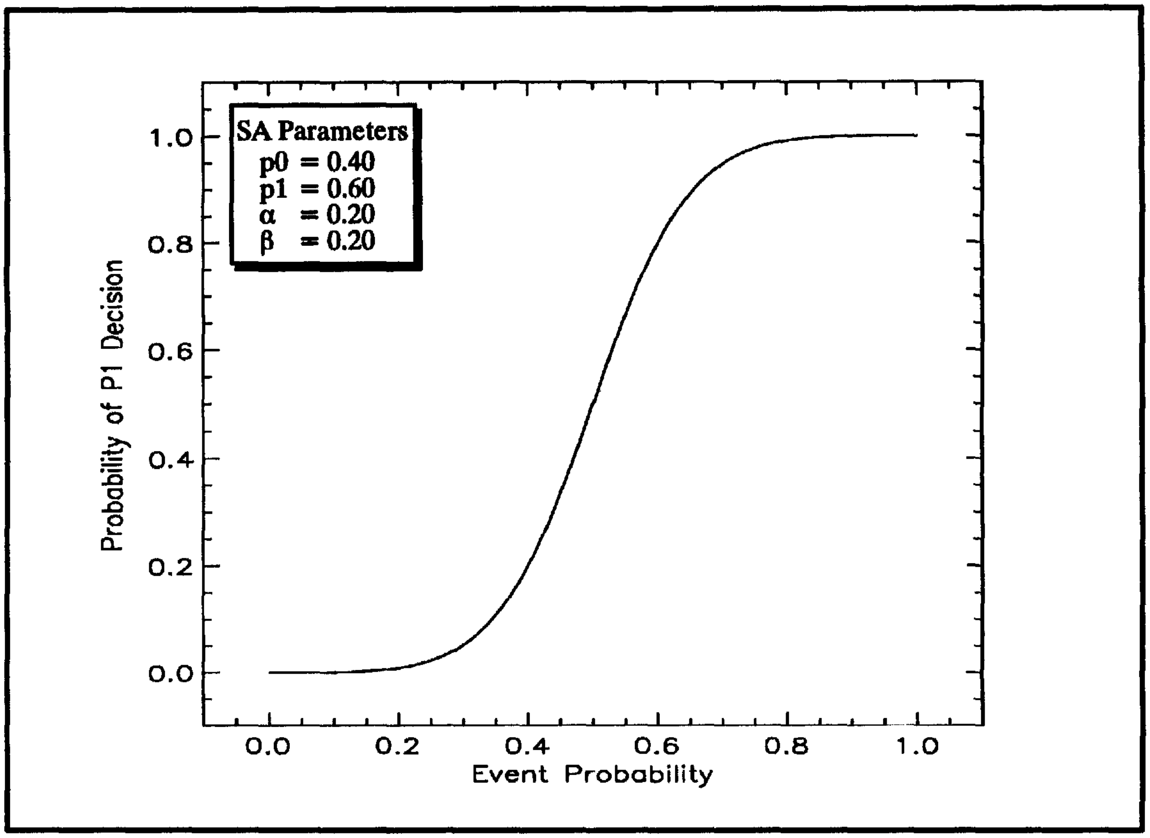


Figure 15. Operating Characteristic Function — 2-Tail

3.4 Protocol

3.4.1 Receiver Selection

Three receivers participated in this study. One (receiver 531) was selected because that individual had produced statistically significant results in earlier similar experiments.[12,13] Two receivers (7 and 83) were selected because of their interest and because of successes in free-response AC experiments.

3.4.2 Target Selection

A Sun Microsystem's SPARC workstation used a feedback shift register algorithm to generate a single binary target for each SA decision trial.[14]

3.4.3 Trial Definition

A trial was defined as an assertive SA decision. That is, either $p = p_1$ or $p = 1 - p_1$. Decisions resulting in $p = p_0$ were tabulated, but otherwise ignored. Each receiver contributed 100 trials.

3.4.4 Sample Definition

An experimental control program oscillated a single binary bit between one and zero as rapidly as possible. When a mouse button was pressed, the state of that oscillating bit represented the value of the single sample.

3.4.5 Trial Protocol

Each trial proceeded as follows:

(1) The receiver started the experimental control program, which asked for the receiver's name.

(2) The program determined if the current trial was a continuation of an earlier trial, or the beginning of a new one.

(3) If the trial was being continued from an earlier session, the program read the previously saved data and indicated that the receiver may begin.

(4) If the trial was a new one, the computer randomly displayed a new target and indicated that the receiver may begin.

(5) The receiver pressed a mouse button to indicate when the oscillating bit matched the predetermined trial target bit. We emphasized that the task for the receiver is a precognition one; press the mouse button at a time when the oscillating bit matches the displayed target bit.

(6) The value of this sample bit was used as input to the SA algorithm.

(7) The receiver ended the session at any time (i.e., either within a trial or at the end of one).

3.4.6 Analysis

The analysis was defined by the SA algorithm. The control program recorded the number of matches between SA decisions (i.e., either one or zero) and the trial target bit. It also recorded the total number of button presses and the number of p_0 decisions that occurred during the 100 SA trials.

The binomial distribution was used to calculate a p-value for each receiver, but the normal approximation to the binomial distribution was used to compute the effect sizes.

4. Results and Discussion

Tables 6 through 8 show the results for receivers 7, 83, and 531, respectively. The z-scores for the binomial methods of analysis are shown for comparison only; since SA does not specify the number of samples, the results tend to be inflated from their correct value. The binomial (decision) method included only those samples that led to a definite SA decision, whereas the binomial (all) method included all samples.

Table 6

Receiver 7

Analysis Method	Hits	Trials	Rate	Z-Score	ε
Sequential Analysis	49	101	0.485	−0.299	−0.030
Binomial (decision)	2,256	4,569	0.494	−0.843	−0.125
Binomial (all)	7,856	15,747	0.499	−0.279	−0.002

Receiver 7 inadvertently produced one extra trial; however, it did not affect the overall score of mean chance expectation (i.e., rate = 0.50). As shown in Section V.3.3, SA did not inflate the chance results beyond what was expected.

Table 7

Receiver 83

Analysis Method	Hits	Trials	Rate	Z-Score	ε
Sequential Analysis	44	100	0.440	−1.20	−0.120
Binomial (decision)	1,916	3,966	0.483	−2.13	−0.034
Binomial (all)	9,422	18,937	0.498	−0.68	−0.005

Receiver 83 produced an overall score of mean chance expectation.

Table 8

Receiver 531

Analysis Method	Hits	Trials	Rate	Z-Score	ε
Sequential Analysis	76	100	0.760	5.20	0.520
Binomial (decision)	2,842	5,059	0.562	8.79	0.124
Binomial (all)	11,008	21,337	0.516	4.65	0.032

Receiver 531 produced an overall significant score (i.e. $Z = 5.2, p \leq 1 \times 10^{-7}, \varepsilon = 0.52$). This receiver is experienced at computer tasks and the result is consistent with his historical performance. A raw hit rate of 0.516 is what is usually seen,[12] and the effect size of 0.032 is consistent with other forced choice AC experiments.

Although only one receiver of three produced significant evidence of AC, the result is illustrative of the technique, and because of 531's previous performance, we consider that this result is not likely to be spurious. While a 16-fold enhancement of effect size was realized by the SA method, it is particularly inefficient; to obtain 100 decisions, 531 pressed the mouse button 21,333 times for an efficiency of 0.47%. It is possible that the efficiency could be improved if the basic SA method could include some adaptive method. That is, the parameters of the analysis could be modified on the basis of the recent scoring rate. If sufficient improvement could be realized, this method might be incorporated as an aid in decision making in practical applications.

VI. MAGNETOENCEPHALOGRAPH

This section comprises the final report for SOW item 6.2.1.

1. Introduction

In a series of electroencephalograph (EEG) experiments conducted at SRI International beginning in 1974, the central nervous system (CNS) of individuals was found to respond to remote and isolated visual stimuli (i.e., a flashing light).[15,16,17] In the first experiment, during randomly interleaved 10-second epochs (i.e., trials), either a flashing light (16 Hz) or no light was present in a sensorially and physically isolated room. Significant decreases of occipital alpha power of isolated receivers were observed by Rebert and Turner.[15] Two replications were conducted in collaboration with Galin and Ornstein at the Langley Porter Neuropsychiatric Institute. As reported by May et al., the results were inconclusive; the first replication confirmed the Rebert and Turner finding, a decrease of alpha power concomitant with the flashing light, but the second replication attempt found an increase in alpha power.[17]

Under another program in FY 1988, SRI International and a biophysics group at a national laboratory conducted an experiment using the magnetoencephalograph (MEG) technique. This experiment was designed as a conceptual extension of the May et al. EEG experiment, although there were significant differences in the protocol. Two types of stimuli were randomly presented to an isolated sender while MEG data were collected from a receiver. The experimental stimulus (i.e., remote stimulus) was a 5-cm square, linear, vertical sinusoidal grating lasting 100 milliseconds. The second stimulus, a control stimulus (i.e., pseudostimulus), was simply a time marker corresponding to a blank screen in the data stream, and was also presented to the sender. There was no change in the alpha power, as reported by May et al., but a *post hoc* analysis revealed a root-mean-square average phase shift of the dominant alpha frequency.[18] A key result of that experiment was that similar "anomalous" phase shifts were obtained for the remote stimuli and the pseudostimuli. Three candidate explanations for these results were suggested. The observed phase shifts might have been:

- Spurious (i.e., statistical deviations within chance expectations)
- Electromagnetic artifacts
- Evidence of anomalous cognition

In order to determine which of these three candidate explanations was correct, we replicated the study at the national laboratory as part of this current effort.

2. Approach

In this section, we provide details of the replication of the 1988 MEG experiment.

2.1 Replication Protocol

2.1.1 Number of Trials

We *assumed* that the observed trial effect sizes that were reported for the previous MEG study resulted from a putative AC effect.[18] Under the remote stimulus condition (i.e., approximately 1,100 trials) we found that the trial-level effect size was 0.060 ± 0.030. In statistical terms, this did not exceed mean chance expectation.

To determine the number of trials necessary to provide a confident replication of the previous experiment, we conservatively used the observed effect size minus one standard deviation (i.e., 0.030). Using traditional statistical power analysis, we found that the probability of observing a significant AC effect in 1,100 trials was 0.258. Conversely, if we require 95% confidence, a significant AC effect could be observed in 12,026 trials, or approximately 120 blocks of 100 trials each.

Twelve individuals were initially identified as receivers for the formal replication; however, because of scheduling difficulties only eight participated in the study. Seven receivers contributed ten blocks each, and one receiver contributed five blocks. The statistical power for 7,500 trials was 0.83, which is the probability of a significant replication over the total of 75 blocks. In this case, a given receiver had a 60% chance of demonstrating an independently significant result if the AC hypothesis is true.

2.1.2 Receiver Selection

Eight experienced receivers, who either participated in the earlier MEG study or were known to be "good" receivers from other investigations, participated in the study.

2.1.3 Sender Selection

An SAIC experimenter acted as sender throughout the study. While it is assumed that a sender is not necessary for AC, it may have a vital psychological function.

2.1.4 Stimuli

The following two types of stimuli were generated by a PC, and consisted of an internal image that could be sent to a standard TV monitor for display:

- Remote stimuli (RS). A low spatial-frequency sinusoidal grating lasting 100 milliseconds was used as a remote stimulus.
- Pseudo Stimuli (PS). All data bytes corresponding to the pseudo stimuli were zero. Thus, the entire video image was a blank screen corresponding to a "time marker" in the data.

An HP workstation controlled 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 was generated $3.0 + 4.5 \times R_{n+1}$ seconds after the *nth* stimulus. The algorithm was seeded from the system clock. The HP notified the PC of the type and time for a stimulus. The PC waited until the next vertical retrace signal from its hardware-video-output board; switched pointers within the retrace cycle from the blank inter-stimulus (IS) frame buffer to one which contains either the RS or PS; and reset the buffer pointers after 100 ms (i.e., the stimulus duration = 100 ms). Figure 16 shows this sequence in graphical form.

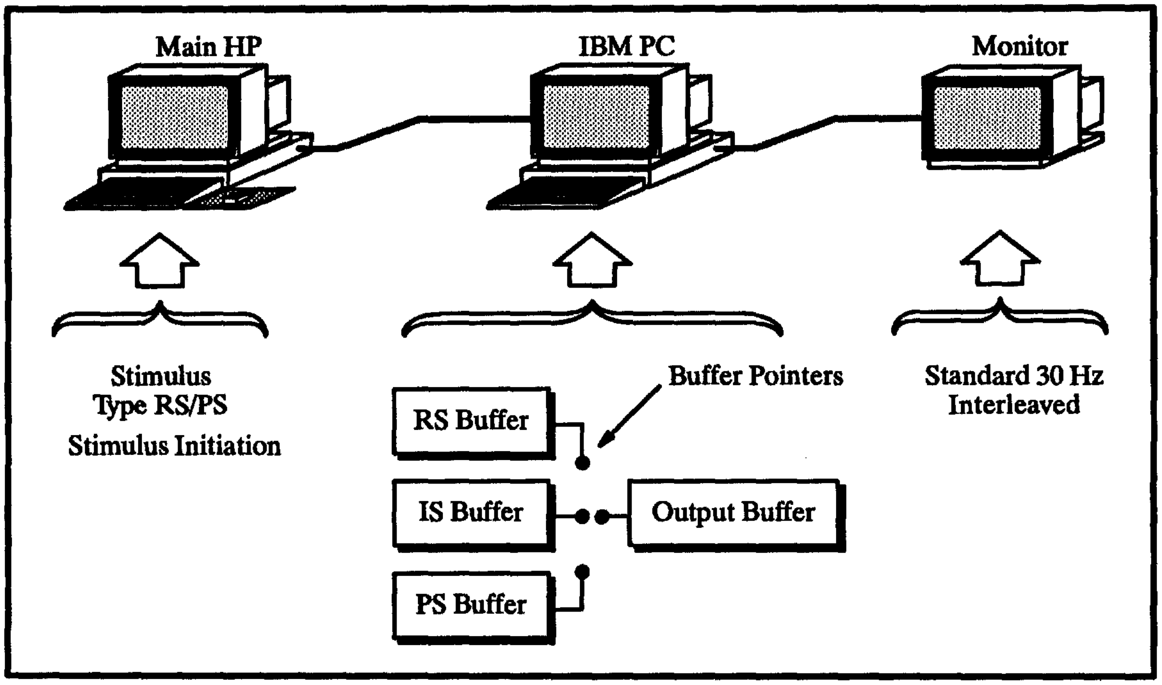


Figure 16. Sequence of Events for Stimuli Generation

2.1.5 Placement of the Seven-Sensor MEG Array

The placement of the seven-sensor MEG array was 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) were collected to produce good signal-to-noise responses. The position of the sensor array, relative to head-based coordinates, was recorded manually on a skull cap, so that the array could be repositioned accurately during subsequent experimental blocks. The array positions that were used during the RS blocks were determined by the maximum response to these direct stimuli. For this portion of the experiment, the stimuli were generated three to four times faster (i.e., ≈ 1 per second) than in the AC portion of the experiment.

2.1.6 Session Protocol

The session protocol was a follows:

(1) Using the marking on the skull cap, the MEG array was repositioned as close as possible to the original calibration location.
(2) Its position was confirmed with direct stimuli, and adjustments were made, if they were necessary.
(3) The designated sender was positioned in front of the remote monitor, which was located approximately 40 m from the receiver.
(4) The video monitor, which presented the direct stimuli, was turned off.
(5) The receiver was instructed to relax with eyes closed. In addition, the receiver was given a few possible strategies that included focusing attention on the display that the sender was observing, on the sender, or on both.
(6) The receiver was notified, by intercom, that the run was about to begin.

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

(8) After five runs, an experimenter quietly entered the MEG room, checked the MEG position, and readjusted it, if necessary. No communication about the status of the experiment was provided.

(9) Five additional runs were collected.

(10) At the end of the block, the receiver entered the control room and was shown a computer display of the results of the last run. The experimenter pointed out interesting portions of the display, but cautioned that the final results required careful analysis of all the runs, not just the last one.

2.1.7 Controls

Two types of controls were used in this experiment to assure the validity of the experimental results:

- **Within-block.** The data in the inter-stimulus times (IS) were used as a within-block control.
- **Between-block.** Using a counterbalanced random protocol, either immediately before or immediately after each 20-minute experiment block, an additional block of ten runs was taken under the same conditions as the experiment block, but without the receiver under the MEG. The sender, however, was "sending" as before.

2.1.8 Data Recording

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

2.1.9 Analysis

2.1.9.1 Overview

A block of data was ten, 2-minute runs. Each block contained approximately 100 RS and 100 PS stimuli, respectively, from each of the seven sensors. The following was 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 periods.
- Averages of the phase shift observed at the dominant α-frequency, which was determined from the centroid of the peak with the largest area above "background" for experiment blocks; 10.0 Hz was used for the between-block controls. The relative phase shift for a single stimulus is defined in Figure 17. The RMS average was computed over the total number of stimuli in the block.

The RMS average phase was the dependent variable for the block. A Monte Carlo calculation was used to determine whether the observed phase shifts deviated from those observed at random times throughout the rest of the block-data record. Each Monte Carlo pass computed the RMS phase over random entry points, which were determined by the same timing algorithm described above, into the same 20-minute data set. The timing algorithm was the same one used during the data collection; however, a new seed started the process on each pass.

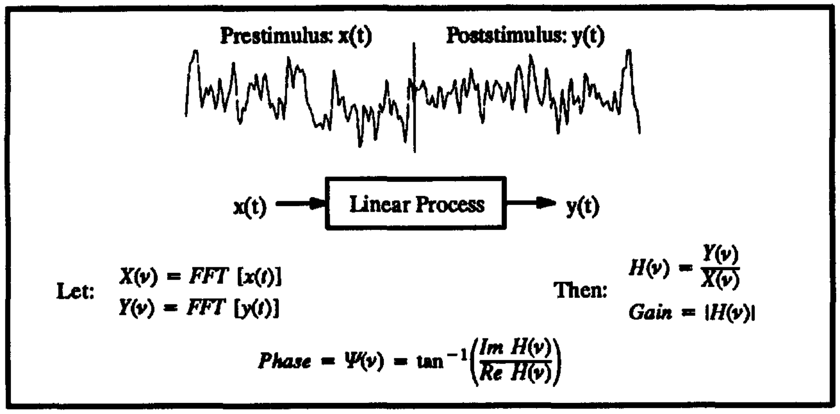


Figure 17. Phase Calculation for a Single Stimulus

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

Conceptually, a 2-tailed z-score was 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 did not specify a direction for a change in phase, the p-value for the block was given by:

$$p = 2 \times P,$$

and the two-tailed z-score was computed from the inverse normal distribution for P. In the experiment, the empirical value of P was used. That is, the number of Monte Carlo-derived RMS phases that were greater than or equal to the observed RMS phase was divided by the total number of Monte Carlo passes. Therefore, the 1-σ error estimate in P were 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 analyst was "blind" to the identity of the receiver, the date, the experiment condition (i.e., experimental or control run), and the stimulus type.

2.1.9.2 Details of the Analysis

Consider N blocks of experimental data. Let n_{jr} be the number of remote stimuli r for block j, and n_{jp} be the number of pseudo stimuli p in block j. Similarly, define ε_{jr} and ε_{jp} as the corresponding effect sizes for block j. We define the weighted effect size for each stimulus type, k, as

$$\bar{\varepsilon}_k = \sum_{j=1}^{N} w_{jk}\varepsilon_{jk},$$

where

$$w_{jk} = \frac{n_{jk}}{\sum_{j=1}^{N} n_{jk}} ,$$

and

$$k = r,p.$$

Tests Against the Null Hypothesis: The Average Effect Size $\bar{\varepsilon} = 0$. Since the experimental effect sizes, ε_{jk}, are derived from normally distributed data (i.e., Monte Carlo calculations of the RMS phase shift), then we know the standard error for each ε_{jk} is

$$sd(\varepsilon_{jk}) = \frac{1}{\sqrt{n_{jk}}} . \qquad (1)$$

Thus, the variance of the weighted average effect size is

$$Var(\bar{\varepsilon}_k) = \sum_{j=1}^{N} w_{jk}^2 Var(\varepsilon_{jk}) = \frac{1}{\sum_{j=1}^{N} n_{jk}} .$$

The z-score associated with $\bar{\varepsilon}$ is

$$Z_k = \frac{\bar{\varepsilon}_k}{\sqrt{Var(\bar{\varepsilon}_k)}} . \qquad (2)$$

Equation 2 is used to test the average effect sizes of the RS and PS for the experimental and control conditions against the null hypothesis of $\bar{\varepsilon} = 0$ for the experimental and control conditions.

Tests Against the the Null Hypothesis: $\bar{\varepsilon}$(RS) − $\bar{\varepsilon}$(PS) = 0. Within a given condition we cannot assume that the phase shifts from an RS are independent from those associated with a PS. Thus, hypotheses tests that do not account for potential correlations between the RS and PS are inappropriate. Because of the simplicity of the individual ε_{jk}, we can compute the exact variance for the differences as follows. Let the difference between the effect sizes for RS and PS be

$$d_j = \varepsilon_{jr} - \varepsilon_{jp}.$$

Since there usually are a different number of stimuli for RS and PS, we define a weighting factor for the d_j as

$$\Omega_j = \frac{n_j}{\sum_{j=1}^{N} n_j} ,$$

where

$$n_j = \frac{n_{jr} \times n_{jp}}{n_{jr} + n_{jp}}.$$

Then the weighted mean difference is given by

$$\bar{d} = \sum_{j=1}^{N} \Omega_j d_j.$$

The variance of $\bar{d}$ is given by:

$$Var(\bar{d}) = \sum_{j=1}^{N} \Omega_j^2 Var(d_j),$$

but

$$Var(d_j) = Var(\varepsilon_{jr}) + Var(\varepsilon_{jp}) - 2\ Cov(\varepsilon_{jr}, \varepsilon_{jp}),$$

but

$$Cov(\varepsilon_{jr}, \varepsilon_{jp}) = \varrho_{rp} \sqrt{Var(\varepsilon_{jr}) \cdot Var(\varepsilon_{jp})}.$$

Combining these equations with the definition for the variance of the effect size, gives the $Var(\bar{d})$ as

$$Var(\bar{d}) = \sum_{j=1}^{N} \Omega_j^2 \left[\frac{1}{n_{jr}} + \frac{1}{n_{jp}} - 2\ \varrho_{rp} \sqrt{Var(\varepsilon_{jr}) \cdot Var(\varepsilon_{jp})} \right],$$

and

$$Z = \frac{\bar{d}}{\sqrt{Var(\bar{d})}}. \qquad (3)$$

Tests Against the Null Hypothesis: $\bar{\varepsilon}$(Experiment)$-\bar{\varepsilon}$(Control) = 0. To compare each stimulus type in the experimental and control conditions, we assume that the data are independent. Thus, the z-score for the difference is given by

$$Z_k(e - c) = \frac{\bar{d}}{\sqrt{Var(\bar{\varepsilon}_k(e)) + Var(\bar{\varepsilon}_k(c))}}$$

$$= \frac{\bar{d}}{\sqrt{\dfrac{1}{\sum_{j=1}^{N} n_{jk(e)}} + \dfrac{1}{\sum_{j=1}^{N} n_{jk(c)}}}}, \qquad (4)$$

where e and c represent the experiment and after-block control conditions, respectively, d is the weighted difference for the stimulus type in the experiment and control conditions.

Equation 4 is used to test the difference between experimental blocks and their corresponding control blocks.

Table 9 summarizes these results.

Table 9.

Hypothesis Testing for Each Receiver

Hypothesis	Test Quantity
1. RS(e) have no effect.	$\sqrt{\sum n_{jr}(e)}\ \bar{\varepsilon}_r(e)$
2. PS(e) have no effect.	$\sqrt{\sum n_{jp}(e)}\ \bar{\varepsilon}_p(e)$
3. RS(c) have no effect.	$\sqrt{\sum n_{jr}(c)}\ \bar{\varepsilon}_r(c)$
2. PS(c) have no effect.	$\sqrt{\sum n_{jp}(c)}\ \bar{\varepsilon}_p(c)$
5. No RS(e)−PS(e) difference.	$\dfrac{\bar{d}(RS - PS)}{\sqrt{\sum \Omega_j^2\left[\frac{1}{n_{jr}} + \frac{1}{n_{jp}} - 2\ \varrho_{rp}\sqrt{Var(\varepsilon_{jr}) \cdot Var(\varepsilon_{jp})}\right]}}$
7. No PS(e)−PS(c) difference.	$\dfrac{\bar{\varepsilon}_p(e) - \bar{\varepsilon}_p(c)}{\sqrt{\frac{1}{\sum n_{jp}(e)} + \frac{1}{\sum n_{jp}(c)}}}$

3. Results

In the experimental condition the effect sizes we measured for the RS and the PS were all well within mean chance expectation for all receivers individually and for the data, which were summed across receivers. This was also true for both stimulus types for the data that were collected during the between-block controls.* All difference statistics shown in Table 9 were also at mean chance expectation.

Formally, therefore, we say that the 1988 study did not replicate, and that those earlier results appear to be spurious.

During the analysis, however, a subtle but major problem was discovered that may render this conclusion, at least, premature. The measurement of instantaneous phase was confounded by noise, so event-related phase shifts might not have been seen with the current analytical technique.

4. Discussion

Using the same analytical techniques that were used in the 1988 study, we did not observe significant alpha activity concomitant with RS; however, we realized, after the fact, that the 1988 analytical technique contained a subtle flaw. We were attempting to measure instantaneous phase shifts of the dominant alpha rhythm in the presence of considerable noise (i.e., the signal-to-noise ratio was approximately 0 decibels). Under this circumstance, the variance of the phase is primarily determined by the noise (i.e., the Crammer-

* Unfortunately, some preliminary results, which were described in an earlier interim technical report, were incorrect. Because of an inadvertent error in the timing parameters, the Monte Carlo calculations were only using the first 10% of the data. Correcting this mistake caused the reported significances to vanish.

Rao relationship[19]). One representation of the Crammer-Rao relationship for the variance of the instantaneous phase, ϕ, is given by

$$Var(\phi) \geq \frac{1}{\Delta T \times R_{SN}},$$

where ΔT is the analysis time (i.e., 0.5 s in our case) and R_{SN} is the signal-to-noise ratio. For our typical brain-wave records, the lower bound for $Var(\phi)$ was approximately 2.67 rad,^{2} or the expected error was 1.63 rad or 93.6 degrees. This estimate is a lower bound, but a more realistic estimate might be higher because of the nonstationary nature of brain-wave data. Thus, if there were phase shifts related to the RS, they likely would have been masked by the noise, and we would not have seen them.

Fortunately, we have saved all the raw data and are able to use an appropriate analysis to determine whether a phase shift occurred concomitant with the RS. We are unable to manipulate R_{SN}; however, we are able, in principle, to extend the analysis time, ΔT, arbitrarily. There are confounding factors that will limit the size of ΔT, so other techniques may have to be employed. In a recent article, Boashash has outlined a number of promising techniques that are specifically developed to address this problem in nonstationary data.[19]

It is important to look carefully at this data because a phase shift, or amplitude shift, should be there, given that the alpha rhythm appears to respond to a variety of non-AC tasks. One such example is event-related desynchronization (ERD). Spontaneous EEG reveals short-lasting, task- or event-related amplitude changes in rhythmic activity within the alpha band. This amplitude change, or desynchronization, is one of the elementary phenomena in EEG. It was first described in 1930 by Berger[20] in scalp EEG as alpha blocking, and was later termed ERD by Pfurtscheller and Aranibar.[21] ERDs can be quantified as a function of time and can then be used to study cortical activation patterns during the planning of motor behavior,[22] sensory stimulation, and cognitive processes.[23,24,25] Kaufman et al. provide a more recent example of cognitive-process-related ERDs.[26] They found a significantly shorter ERD when subjects simply responded to a target stimulus, compared with the ERD that occurred when a subject had to search visual memory to determine whether the target matched one previously presented.

If we take the historical behavioral AC data as evidence of an anomaly, it would be surprising not to find some form ERD, given we can provide the proper stimulus.

5. Suggested Research

Aside from the technical difficulties associated with the Crammer-Rao relationship, all of our earlier attempts to identify CNS correlates to AC did not contain any concomitant behavioral measure of AC; therefore, we have no independent measures that AC functioning occurred in these experiments. Also, the conditions under which experiments were conducted were not similar to those known to be conducive to the production of AC data. For example, there is no evidence that a flashing light constitutes a valid AC target. It is also likely that when a receiver is asked to recline face down in a MEG laboratory, that the conditions for the receiver are not optimal.

We suggest that new experiments be designed to measure CNS responses to AC stimuli. Since we will not be initially concerned about source localization, we will not immediately require the special properties of a MEG.

Specifically, we suggest the following as remedies to the problems that were described above. In series of EEG experiments:

- Use stimuli that are identical to those in standard AC experiments.
- Demonstrate CNS correlates to these stimuli when they are directly presented to receivers.
- Provide a potential for independent, but concomitant, behavioral evidence for AC.

In addition, we suggest that the experiments should use EEG measures that more closely resemble those that are used in more traditional psychophysiological experiments. In this way, conditions are optimized to observe ERDs that may be related to AC stimuli.

VII. ENHANCING DETECTION OF AC WITH BINARY ENCODING

This section comprises the final report for SOW item 6.2.3.3.

1. Objective

The objective of this pilot study was to use a two-by-five error correcting block code to improve the detection of AC.

2. Background

AC responses usually are narrative descriptions, which have been difficult to quantitatively assess. A number of analysis techniques have been developed to deal with this problem. In one of the earliest techniques, an analyst visited potential target sites and ranked them from best to worst match for each AC response. The analyst had to determine subjectively the boundaries of the target and the elements that were to be included in the analysis.[6]

During the next phase of the development, the target and the response were reduced to their individual conceptual attributes. The analyst then had to compare lists of discrete attributes; one defining the response and one each for the potential targets. This all-or-nothing binary determination proved to be inappropriate for an inherently imprecise situation.[27,28]

Fuzzy sets were then used to allow a gradation of judgment in defining specific elements of content within both the target and the response. This method, however, proved to be labor intensive and did not significantly improve the stability and reliability of AC analysis.[7]

This pilot experiment was designed to explore the potential for maximizing the reliability of AC responses through objective and rapid analysis. We have reverted to using a dichotomous binary procedure as opposed to a fuzzy set technique. By carefully selecting the dichotomous elements and by using standard block coding techniques to incorporate all single and a few double error corrections, the earlier problem of all-or-nothing binary determinism might be reduced. A message sending motif was used as a test-bed for this kind of analysis.

3. Approach

This pilot experiment was similar to a traditional AC experiment: a target was selected randomly; a receiver was asked to describe information that was not available to currently known sensorial channels; and a quantitative assessment of the match between the target and the AC response was made. It differs only in the construction of the target pool and in the quantitative analysis.

3.1 Targets

The targets were all photographs from the *National Geographic* magazine. A special target pool was constructed consisting of 10 packs, each of which contained four targets. Each target was described in terms of permutations of five fixed attributes. Each target pack had its own individual set of five attributes, and each photograph was represented by a binary encoded number indicating the presence (i.e., binary one) or absence (i.e., binary zero) of each of the five attributes.

Table 10 shows the assigned attributes for each of the 10 target packs:

Table 10.

Attributes for Ten Target Packs

Pack	Bit Position				
	0	1	2	3	4
1	Repeat Motif	Action	Mountains/Cliffs	Vehicle	Manmade Structure
2	Towers	Vehicles	Mountains/Cliffs	Water	Buildings
3	Vehicle	Arch/Dome	Stepped	Buildings	Vegetation
4	Building	Circle	Rectangle	Triangles	Repeat Motif
5	Square/ Rectangle	Mountains/ Cliffs	Action	Natural	Arch/Dome
6	Mountain/ Hill	Water	Action	Building	Natural
7	Action	Water	Industrial	Vehicle	People
8	People	Natural	Vehicle	Vegetation	Buildings
9	Water	Mountains/ Hills	Buildings	Rural	Road/Bridge
10	People	Industrial	Mountains/Hills	Tower	Vehicle

For example, to construct the binary number 10101 from pack one, we found a photograph that contained a repeat motif, mountains/cliffs, and manmade structures, but did not contain action or vehicles. The error-correcting code that we are using required us to construct the following four binary numbers: 00000, 01110, 10101, and 11011 (see Figure 18, on page 52), that is, two "message" bits (i.e., first two from the left) and three "check" bits. Using the attributes shown in Table 10, we identified four photographs for each pack that satisfied these restrictions. Each of the four binary numbers were then represented by a single photograph within each target pack.

3.2 Target Selection

For each trial in this experiment, a pseudo random number generator was used to select a pack and one of four possible photographs within the pack to serve as a target.

3.3 Receiver Selection

Five receivers were selected to participate in this experiment on the basis of their significant results from previous AC experiments.

3.4 Protocol

3.4.1 Number of Trials

The five receivers contributed eight trials each.

3.4.2 Trial Protocol

Before the experiment began each receiver was provided with instructions and a list of dates on which targets were to be at a prearranged location in the Menlo Park laboratory. The following steps were performed for each trial:

(1) The PI used a pseudo random number generator to select a photograph (i.e., a binary number) from the target pool and placed the photograph in a previously agreed upon location. This target remained in the designated location for one week for the convenience of the receiver. Receivers had access to the target, by AC methods only, at any point during this time period, since no senders or session monitors were involved in this study.

(2) Receivers were to find a quiet place in their homes to work with pen and paper. For a period lasting no longer than 15 minutes, each receiver was to write and draw his/her impressions of the target.

(3) The responses were sent by facsimile to the PI.

(4) The PI sent back a sheet of five questions about the target, which could be answered by "yes" or "no." These questions pertained to the five target attributes for the target pack from which the designated target was chosen (e.g., Does the target contain triangles?).

(5) The answers were sent back to the PI for analysis. Upon receipt, the PI provided a copy of the target photograph as feedback.

(6) This procedure was repeated until eight trials were obtained from each receiver.

3.4.3 Analysis

At the end of the experiment, the PI removed the name, date, and time from each response; randomized the order of the responses; and provided an analyst with the responses and associated target packs. The intended target was not disclosed. Three different methods of analysis were used in this experiment:

- Rank ordering
- Number decoding (analyst)
- Number decoding (receiver)

3.4.3.1 Rank-Ordering

Traditional rank-ordering was the first method of analysis. When a target was chosen from one of the target sets, the remaining three targets were considered "decoy" targets for an analyst. For each trial, an analyst was given the AC response and the target pack (i.e., four targets) from which the actual target was chosen. The analyst was required to rank order the targets within the designated pack from best to least match to the response, regardless of the quality of the matches. The rank that was assigned to the intended target represented the value of the dependent variable for the trial. A sum-of-ranks was then computed for all trials for each receiver. Effect sizes and p-values were determined from the known sum-of-ranks distribution. This method was used to determine the level of AC functioning for each receiver in the study. In addition, the number of direct hits (i.e., first place ranks) was computed for each receiver and the binomial distribution was used to compute p-values and effect sizes from this perspective.

3.4.3.2 Number Decoding (Analyst)

For each response, an analyst, who was blind to the binary number for each trial, answered the same set of questions that were sent to each receiver. In this way, the AC response was converted into a 5-bit binary number. Figure 18 shows the decoding matrix, which is specified by the block coding.

00000	01110	10101	11011	Targets
00001	01111	10100	11010	Single Error Correction
00010	01100	10111	11001	
00100	01010	10001	11111	
01000	00110	11101	10011	
10000	11110	00101	01011	
00011	01101	10110	11000	Double Error Correction
01001	00111	11100	10010	

Figure 18. A Two-by-Five Bit, Error Correcting Block Code

The PI then used the answers provided by the analyst to locate the 5-bit binary number from the decoding matrix. The actual target binary number is the one represented by the 5-bit code that tops the column in which the encoded AC response is found. This matrix allows for correction for all single bit errors and a number of two bit errors within the AC response.

3.4.3.3 Number Decoding (Receiver)

It has been observed anecdotally that receivers, when asked to perform analytical tasks on their own data, are not accurate. To test this hypothesis, the five questions answered by the receivers for each trial were translated into their own 5-bit assessment of the target. This was used to access the decoding matrix.

4. Results

4.1 Rank-Ordering

The rank-order method of analysis was used to determine the level of AC functioning for each receiver in this study. The results can be seen in Table 11 below. Because the target was the same for all receivers in a single trial, we did not compute statistics across receivers. In this way, we avoided a stacking problem.

Sum-of-ranks and mean-of-ranks statistics were computed for the eight trials for each receiver. We calculated the p-values and examined the magnitude of the effect sizes on a receiver-by-receiver basis. No receiver produced a significant p-value, while only one receiver (454) had an effect size larger than 0.20.

In Table 11, ΣR is the sum-of-ranks, $\bar{R}$ is the average rank, and the p-value is computed from the sum-of-ranks distribution. The effect size is shown for comparison.

Table 11.

Statistics for the Sum-of-Ranks

Receiver ID	ΣR	$\bar{R}$	p-value	Effect Size
009	21	2.625	0.6797	−0.1118
083	25	3.125	0.9597	−0.5590
372	20	2.500	0.5617	0
389	19	2.375	0.4383	0.1118
454	18	2.250	0.3203	0.2236

In addition, the number of direct hits (i.e., first place ranks) were computed for each receiver and the binomial distribution was used to compute p-values and effect sizes from this perspective.

In Table 12, h is the number of first place ranks computed for each receiver.

Table 12.

Statistics for First Place Ranks

Receiver ID	h	p-value
009	1	0.900
083	0	1.000
372	2	0.633
389	1	0.900
454	2	0.633

4.2 Number Decoding

The number decoding method of analysis was used to test two hypotheses:

- A two-by-five, error correcting block code can be used to improve the detection of AC.
- Receivers who are asked to perform analytical tasks on their own data are not as accurate as an independent analyst.

The results of decoding by the receiver are shown in Table 13. The number of direct hits (i.e., event probability of 0.25) is shown as h. The p-value is computed from the exact binomial distribution.

Table 13.

Receiver First Place Ranks

Receiver ID	h	p-value
009	2	0.633
083	3	0.322
372	3	0.322
389	2	0.633
454	3	0.322

The results of decoding by the analyst are shown in Table 14. The number of direct hits (i.e., event probability of 0.25) is also shown as h. The p-value is computed from the exact binomial distribution.

Table 14.

Analyst First Place Ranks

Receiver ID	h	p-value
009	1	0.900
083	1	0.900
372	2	0.633
389	2	0.633
454	3	0.322

Z-scores were computed for each of the p-values in Tables 13 and 14 using an inverse normal distribution, and they were combined in each table by Stouffer's-z (i.e., -0.317 and -1.243, respectively). The z of the difference is 1.10, which corresponds to an effect size of 0.493. While neither receiver nor analyst produced significant matches in the block coding analysis, the receivers appeared to be better at assessing their internal responses than were third-party analysts. The number of trials is small and, as we note below, the study had difficulties; therefore, we urge caution in interpreting the results.

5. Discussions and Conclusions

The primary consideration in this pilot study was to determine if binary coding could enhance the detection of AC. Only one receiver, however, demonstrated an effect size larger than 0.20 (i.e., 0.22) for evidence of an AC phenomena and no evidence of enhanced detection of AC was seen.

The following difficulties may have rendered the results inconclusive:

- Although the question sets were different for each target pack, the receivers reported that they attempted to guess what the questions would be while producing individual AC responses. This may have reduced a free-response AC trial to a forced-choice one, which is known to be significantly less robust.
- In an attempt to make the targets dichotomous within packs and at the same time interesting to view, targets within the pool ranged in scale from a panoramic scene of a cityscape to a photograph of three

chairs to an image of three geometric shapes, and thus possessed a large target-pool bandwidth. Since receivers were told in advance that the targets could contain absolutely any material, they were unable to censor their internal experiences, which may have resulted in enhanced intrinsic receiver noise (see Section IV.5.3).

- Each encoding bit was linked to only one percept (e.g., the single target element of water). This exaggerated the importance of the chosen dichotomous elements. For example, if a receiver failed to sense water in the target but managed to sense most other aspects of the target that were not part of the bit structure, then the block coding was not particularly applicable.
- In an AC application, a fundamental imbalance exists in the bit structure. The block coding assumes that binary zero is "assertive." That is, in AC when *water* is not indicated in the response, it is equivalent to indicating the *water* is definitely not in the target. In AC experiments, however, unless a receiver specifies explicitly that *water* is not present, then the presence or absence is indeterminate. Maybe water exists in the target but was not noticed or was unreported by the receiver. Similarly, *water* may not exist in the target and a non-response is equivalent to an assertive no. These two cases are, of course, indistinguishable. The net effect is to render the block coding invalid.

Because of these difficulties, we recommend that the experiment be repeated with the following improvements:

- Reduce the target-pool bandwidth by using the *National Geographic* static target pool, which has been successful for many AC experiments.
- Reduce the sensitivity to single block encoding bits by incorporating a number of fuzzy-set elements for each bit. Thus, each bit will not rely upon a single percept, but rather represent classes of different percepts.

We anticipate that these improvements will allow for much stronger AC, and provide a more sensitive test of whether binary error-correcting can be successfully applied to AC detection.

VIII. SUBCONTRACTS

Under this current effort we let three subcontracts to address specific items in the SOW.

1. Edinburgh University

This section constitutes part of the final report for SOW item 6.2.3.2.

We subcontracted to the Psychology Department of Edinburgh University to construct an isolation room, which was designed specifically for Ganzfeld studies. The room is now complete and pilot Ganzfeld trials are being conducted.

As part of their statement of work, we specified that the sound attenuation characteristics of the Ganzfeld isolation room must be measured. The Department of Building Engineering and Surveying of Heriot-Watt University was asked to conduct the appropriate measurements.

We find that the room is sufficiently physically isolated from the sender's location and the sound attenuations is reasonable for Ganzfeld studies.

2. Psychophysical Research Laboratories (PRL)

This section constitutes the final report for SOW item 6.2.2.4, the remainder of item 6.2.3.2, and item 6.3.2.2.

To assist in our ongoing effort to determine what variables might be important in AC experiments, we subcontracted with Mr. Charles Honorton, the director of PRL, to improve an earlier meta-analysis of the literature pertaining to characteristics of persons who might perform well in AC tasks. Specifically, he found that good novice Ganzfeld performers reported personal experience with natural AC, participated in earlier AMP experiments, were involved with mental disciplines such as meditation, and tended toward the Intuition side of the Sensing/Intuition scale of Myers-Briggs Type Indicator. Honorton's complete report can be found in Appendix B.

As part of our effort to understand the role of the sender in AC experiments, we asked Mr. Honorton to conduct a meta-analysis of the Ganzfeld literature to determine if there were meaningful differences between Ganzfeld studies with and without a sender. Unfortunately, there were insufficient numbers of Ganzfeld experiments conducted in the clairvoyant mode (i.e., without a sender) to be able to ascertain, from the published literature, the sender's role. Appendix C contains Mr. Honorton's detailed meta-analysis of the available literature.

Because the results of the meta-analysis proved to be inconclusive, PRL was tasked to design a protocol for a definitive Ganzfeld study to understand the role of the sender in such experiments. That protocol, detailed in Appendix D, superimposes on the standard auto-Ganzfeld procedure an additional 4-state sender condition. That is, the sender is either:

(1) Blind to all aspects of the target material
(2) Shown only the audio content of the target material
(3) Shown only the video content of the target material
(4) Shown the audio and visual content of the target material

During a Ganzfeld trial, the experimenter and receiver will be blind to which of these conditions is operative.

3. The Lucidity Institute

This section constitutes the final report for SOW item 6.2.4.1. The Lucidity Institute's final report, which can be found in Appendix E, contains the complete details of the results of the study. We provide our perspective on the experiment in this section.

3.1 Objective

The objective of this investigation was to determine if anomalous cognition can be observed during a lucid dream.

3.2 Background

Dreams involving putative AC have been part of every human culture from the times of ancient Greece to the present. The first serious attempt, however, to examine AC in dreams under controlled conditions began under the direction of Montague Ullman, MD, in 1962 at the Community Mental Health Center of the Maimonides Medical Center in Brooklyn, New York. The research of AC in dreams continued until 1972, when the dream protocol was abandoned in favor of a simpler and more rapid approach to the study of AC. Child has summarized and critiqued this body of research in the *American Psychologist.*[29]

In these studies, individuals were asked to sleep in a laboratory and be monitored for brain activity and eye movement. From these records, it was possible to tell when they were dreaming. Upon the onset of rapid eye movement (REM), an experimenter notified a sender, who was isolated in a remote laboratory, to begin attending to a randomly selected target. At the end of the REM period, the dreamer was awakened and asked to report the dream content. This procedure was repeated throughout the night using the same target material for each separate dream (e.g., up to ten). The assessment of the AC content was accomplished through independent judges. As described by Child, significant evidence for AC was observed under a variety of conditions.

The dreamers in these studies, however, were not necessarily focused upon the AC task. They slept as usual and, when asked, reported their dream content. In our pilot study we focused the dreamer explicitly on the AC task using the methods of lucid dreaming.

A lucid dream is one during which the sleeper becomes consciously aware that the experience is a dream as opposed to the waking state. LaBerge et al. (1981) have found that it is possible for dreamers to know when they are dreaming and to signal the waking world through predetermined eye movements indicating their awareness.[30] Using this ability, LaBerge et al. (1986 and 1988) conducted psychophysiological studies to determine the differences between waking and dreaming from that perspective.[31,32] They found that dreaming is similar to the waking state. Motor action is mostly inhibited from the brain stem downward; however, the cerebral cortex appears not to "know" this.

In this preliminary pilot study, we used the skills developed by LaBerge to teach individuals to lucid dream. Differing from the earlier AC dream studies, our dreamers were instructed to adopt a proactive attitude to seek out and remember the AC target. In this way, we tried to determine the degree to which lucid dreaming can facilitate the reception of AC material.

3.3 Approach

3.3.1 Receiver Selection

We used two specialized populations from which we drew receivers for this pilot experiment:

(1) Experienced dreamers from LaBerg's research subjects (three receivers)

(2) Receivers who have demonstrated significant ability in other AC studies (four receivers)

3.3.2 Target Selection

Targets were chosen randomly from the standard set of 100 *National Geographic* magazine photographs.

3.3.3 Trial Definition

A trial was defined as a successful lucid dream during which the target material was examined and later transcribed in the waking state.

3.3.4 Lucid Dream Protocol

All receivers undertook two forms of training in lucid dreaming: (1) They completed a lucid dreaming home-study course developed by the Lucidity Institute, and (2) they attended two weekend seminars, one at the beginning and one at the end of a three-month pilot study. The first seminar, which was held in December, 1991, introduced receivers to lucid dreaming skills and the use of the DreamLight™, a lucid dream induction device. In previous studies, the DreamLight™ has been shown to enhance the frequency of lucid dreaming. The DreamLight™ consists of a sleep mask equipped with lights and eye movement sensors, which are attached to a small battery-operated computer. When the computer detects the eye movements of dreaming (i.e., REM) sleep, it causes the lights in the mask to flash briefly (i.e., either one or two flashes per second). The dreamer frequently incorporates the flashes into the ongoing dream, and thus experiences a cue to indicate that he or she is dreaming. Receivers had access to DreamLights™ during the duration of the study.

3.3.5 AC Baseline Measures

The three inexperienced receivers from the Lucidity Institute were asked to contribute eight AC trials in a waking state in the Cognitive Sciences Laboratory as an AC baseline series. The targets for these series were chosen at random from the standardized target set. Each trial was conducted as follows: After the receiver and a monitor entered the AC laboratory (i.e., an office with a single desk and two chairs), an assistant used a computer random number generator to select a target from the baseline target pool. Both the receiver and the monitor were blind to this specific choice. At a pre-arranged time, the monitor encouraged the receiver to draw and write impressions of the target material, which was located approximately 30 m away. After approximately 15 minutes of casual questioning, the trial ended; the data were copied; the originals were secured; and the actual target was presented as feedback to the receiver.

3.3.6 Protocol for a Lucid-Dream Trial

During this study, a lucid-dream trial for each receiver was conducted as follows:

(1) The receiver was given a sealed opaque envelope containing a target photograph chosen randomly from a predetermined set of 100. The receiver placed the target envelope in the room in which he or she was going to sleep.

(2) Using the DreamLight™, the receiver attempted, while dreaming, to open the envelope, memorize its content, and awaken as soon as possible.

(3) In the waking state, the receiver wrote and drew his or her impressions in detail.

(4) During the next day, the unopened envelope and the response was mailed to the PI for analysis. Upon receipt, the PI sent back a copy of the target photograph as feedback and an additional sealed envelope for the next trial.

Traditional rank-ordering was the method of analysis. In addition, each trial was assessed using the *post hoc* scoring method, which is shown in Table 3 on page 21.

3.4 Results and Discussion

A total of 21 trials were collected in this pilot study. Summed across receivers, we observed significant evidence for AC (i.e., $z = 1.69$, $p \leq 0.046$, *effect size* = 0.368). During the calibration series, one of Lucidity Institute's receivers obtained evidence for AC (i.e., *effect size* = 0.265); however, the other two receivers showed little overall evidence of AC. As is common in novice receivers, who may have innate AC ability, the quality is highly variable. On those rare cases when a first place rank was assigned, the quality scores were quite good. Because of the limited number of lucid dream trials, we were not able to ascertain the degree to which the lucid dream state improves the quality of AC; however, we are able to say that it does not inhibit AC.

We are encouraged by these results for so few trials and suggest that the experiment be repeated with the following improvements:

- Conduct the lucid dreaming AC trials in the laboratory. During the pilot study, the receivers could not reliably produce lucid dreams. This hit-and-miss approach can be markedly improved in the laboratory. Receivers can be awakened at the end of a dream, which has been observed to be lucid by eye signals, and queried about their experience. In addition, the setting of the laboratory is likely to be more conducive for lucid dreaming.
- Provide immediate feedback at the end of the overnight session.
- Monitor various psychophysiological variables so that the lucid dream state can be more accurately defined.

IX. OTHER ACTIVITY

1. Correlations between AC and Geomagnetic Activity

This section comprises the final report for SOW item 6.2.2.3.

1.1 Background

Persinger, Tart, Krippner, and others have reported an association between AC performance and indices of geomagnetic field (GMF) fluctuations. This work has shown that both anecdotal reports of spontaneous AC, as well as higher-scoring laboratory AC trials, tend to occur at times of relatively low GMF activity. The published evidence is not entirely compelling. The anecdotal AC data are contaminated to an unknown extent with confounding factors of reporting bias, timing errors, and the difficulty of establishing the veracity of such reports *post hoc*. The retrospective studies of laboratory AC data, while largely free of these problems, have demonstrated only small correlations to GMF indices. There is, however, increasing interest in the possibility of biological effects of small amplitude magnetic field variations. Recent work has shown that melatonin and serotinin levels are modulated by GMF activity both in vivo and in vitro. Other research is exploring the physics of possible mechanisms whereby low-amplitude magnetic field variations could interact with cells.

1.2 Anomalous Cognition

To investigate the relationship between scores in laboratory AC experiments and GMF fluctuations, we are combining various experimental databases. Currently, we have assembled a database of approximately 1,000 free-response AC trials from several laboratories. There is a very small (i.e., $\varrho = -0.05$, $p \leq 0.09$) correlation between trial scores and GMF fluctuations in the expected direction in this database. The correlation, however, is much larger (i.e., $\varrho = -0.40$) in those experiments where significant AC was demonstrated.

1.3 Epilepsy

We may discover more about the impact of GMF fluctuations on AC performance by research on other behaviors that are modulated by very low frequency magnetic fields. Some literature suggests a connection between idopathic and epileptic seizures and GMF fluctuations. Currently, we have assembled a database of approximately 4,000 seizures and seizure-related mortalities. Preliminary analysis of a subset of this database suggests that both seizures and mortalities associated with seizures are weakly correlated with elevated GMF noise levels. GMF noise might be depressing the melatonin level, resulting in an increased probability of seizure. We have submitted a paper, which describes the results of the GMF/epilepsy investigation, for publication in the British medical journal, *The Lancet*. This paper may be found in Appendix F.

2. Assessment of Theoretical Constructs

This section comprises the final report for SOW item 6.2.3.1.

One senior research physicist has been identified who is anxious to explore thermodynamic and general relativistic models to formulate hypotheses for the mechanism of AC.

The data from AMP experiments have begun to suggest theoretical approaches toward understanding the underlying principles for the phenomena. Most of the previous modeling has been quantum mechanical,[33,34] metaphoric,[35] or behavioral[36] and generally has not led to testable hypotheses. One heuristic model does suggest experiments, but it does not provide fundamental insight into the mechanisms of AC.[37] We suggest a variety of different theoretical approaches that are either dictated by the strength of the AC data or are strongly suggested by fundamental concepts.

Specifically, we suggest that theoretical approaches from among the following should be examined to determine those that are most likely to provide testable hypotheses (i.e., new protocols or experiments) and lead us toward a theoretical understanding of the physics of AC.

The Einstein, Poldasky, Rosen (EPR) Paradox. The paradox suggests possible information transport during the collapse of a wave function. The paradox arises naturally when considering two-particle correlations and the effect of measuring the state of one particle, which gives rise to unambiguous knowledge of the state of the correlated particle. While no one any longer questions the validity of the predictions of quantum mechanics for correlated systems, the fact of that validity has caused a philosophical revolution. There is no underlying reality—no absolute reality. There is only reality as defined by measurements made by an observer. This approach is suggested because AC experiments appear to show "correlation" of separated events. While it is doubtful that AC is quantum mechanical, nonetheless the EPR formalism might provide conceptual insight into possible AC mechanisms.

Thermodynamic Entropy. For nearly two hundred years, scientists have taken the position that the entropy of a closed system can never decrease with time and that, on the scale of the universe, entropy always increases with increasing time. Recently, Steven Hawking has raised the possibility that macroscopic time or psychological time, the time that we perceive, is actually determined by the change of entropy.[38] The study of classical thermodynamic entropy appears likely to be the most productive based upon the results of a recent Shannon entropy experiment[39] and on the extensive evidence for so-called precognition—AC of targets *before* they have been determined.[40]

General Relativity. Matt Visser's paper on traversable wormholes suggests that it is physically possible to transport energy (and, therefore, information) between remote space-time points without traversing the classical distance between the space-time events.[41] General relativity, therefore, is a candidate for a theoretical basis for AC.

Tachyons. It is possible to describe mathematically a fully consistent universe in which everything moves faster than the speed of light. The particles inhabiting such a universe are named tachyons while, in contrast, the particles with which we are familiar are named tardyons. The important fact is that neither particle can ever travel at the speed of light. Photons, of course, are common to both universes. Moreover, this is a non-quantum mechanical description. Theoretical understanding of tachyons may assist in defining an energy transfer mechanism for AC.

Fuzzy Set Attributes and Levels

Attribute	Description	Level
1	Fort	10
2	Castle	10
3	Palace	10
4	Church, Religious	10
5	Mosque	10
6	Pagoda	10
7	Coliseum, Stadium, Arena	10
8	Bridge	9
9	Dam, Lock, Spillway	9
10	Boats, Barges	9
11	Pier, Jetty	9
12	Motorized Vehicles	9
13	Column	9
14	Spire, Minaret, Tower	9
15	Fountain	9
16	Fence	9
17	Arch	9
18	Wall	9
19	Monument	9
20	Roads	8
21	Port, Harbor	7
22	Oasis	7
23	Agricultural Fields	7
24	Industrial	7
25	Recreational	7
26	Religious	7
27	Mechanical	7
28	Technical	7
29	Agricultural	7
30	Commercial	7
31	Wilderness	7
32	Urban	7
33	Rural, Pastoral	7
131	Historical/Archaeological	7
34	Ruins, Incomplete Buildings	6

Fuzzy Set Attributes and Levels (continued)

Attribute	Description	Level
35	Mesa, Plateau	6
36	Waterfall	6
37	Glacier	6
38	Canal, Manmade Waterway	6
39	Desert	6
40	Forest	6
41	Jungle	6
42	Marsh, Swamp	6
43	Isolated Settlement	5
44	Town, Village	5
45	City	5
46	Single Peak	5
47	Hills, Slopes, Bumps, Mounds	5
48	Mountains	5
49	Cliffs	5
50	Plain, Delta	5
51	Valley, Gully, Cleft	5
52	Canyon	5
53	Crater, Regular Depression	5
54	Unbounded Large Expanse Water	5
55	Completely Bounded Water	5
56	Partially Bounded Water	5
57	Island	5
58	River, Stream, Creek	5
59	Coastline	5
60	Vegetation, Trees	5
61	Yellow	4
62	Orange	4
63	Red	4
64	Blue	4
65	Green	4
66	Purple, Pink	4
67	Brown, Beige	4
68	Black	4
69	White	4

Fuzzy Set Attributes and Levels (continued)

Attribute	Description	Level
70	Grey	4
71	Shiny, Reflective	4
72	Gold	4
73	Silver	4
74	Chrome	4
75	Copper	4
76	Obscured, Fuzzy, Dim, Smoky	4
77	Cloudy, Foggy, Misty	4
78	Old	4
79	Weathered, Eroded, Incomplete	4
80	Smooth	4
81	Fuzzy	4
82	Grainy, Sandy, Crumbly	4
83	Rocky, Ragged, Rubbled, Rough	4
84	Striated	4
85	Hot	4
86	Cold, Snow, Ice	4
87	Humid	4
88	Dry, Arid	4
89	Flowing	4
90	Other Implied Movement	4
91	Congested, Cluttered, Busy	4
92	Serene, Peaceful, Unhurried	4
93	Closed In, Claustrophobic	4
94	Open, Spacious, Vast	4
95	Ordered, aligned	4
96	Disordered, Jumbled, Unaligned	4
97	Buildings, Structures	3
98	Rise, Vertical Rise, Slope	3
99	Flat	3
100	Light/Dark Areas	3
101	Boundaries	3
102	Land/Water Interface	3
103	Land/Sky Interface	3
104	Single Predominant Feature	3

Fuzzy Set Attributes and Levels (continued)

Attribute	Description	Level
105	Odd Juxtaposition, Surprising	3
106	Manmade, Altered	3
107	Natural	3
108	Rectangle, Square, Box	2
109	Triangle, Pyramid, Trapezoid	2
110	Other Polygonal, Hexagon	2
111	Cross–Hatch, Grid	2
112	Circle, Oval, Sphere	2
113	Torus	2
114	Cylinder	2
115	Cone	2
116	Semicircle, Dome, Hemisphere	2
117	Irregular Forms	2
118	Repeat Motif	2
119	Stepped	1
120	Parallel Lines	1
121	Vertical Lines	1
122	Horizontal Lines	1
123	Diagonal Lines	1
124	V–Shape	1
125	Inverted V–Shape	1
126	Other Angles	1
127	Arc, Curve	1
128	Wave Form	1
129	Spiral	1
130	Meandering Curve	1

Physical Interpretation of Potentials. Classical mechanics and, for the most part, quantum mechanics have treated potentials as convenient mathematical descriptions for which there are no physical counterpart. Recent experiments have shown, however, that a potential can affect a particle even when there is no corresponding force present. If potentials could be made to propagate, then they could be candidates for an energy transfer mechanism for AC.

3. Anomalous Perturbation

This section constitutes the final report on SOW item 6.2.5.

At the sponsor's request, we provided two receivers to participate in an informal and exploratory anomalous perturbation experiment. The target system was a special E&M wave device; there was no particular protocol; and we report, in the form of a laboratory anecdote, that a sufficiently large number of unexpected events occurred to suggest that additional and more formal data must be collected.

4. Fuzzy Set Analysis

This section constitutes the final report on SOW item 6.3.2.1.

4.1 Background

The elements in our fuzzy set representation of our target pool are structured in *levels*, ranging from the relatively abstract, information poor (such as vertical lines—level 1), to the relatively complex, information rich (such as churches—level 10). The current system is structured into seven primary and three secondary levels of descriptors; the main intent of this structure is to serve as a heuristic device for guiding the analyst into making judicious concrete descriptor assignments based on rather abstract commentary. The determination as to which descriptors belonged on which level was made after consideration of two primary factors: (1) the apparent ability of receivers' to resolve certain features, coupled with (2) the amount of pure information thought to be contained in any given descriptor. Some of these "factor one" determinations were based on observations of analysts and monitors in the course of either analyzing or conducting numerous AC experiments and on subjective lore; some were determined empirically from *post hoc* analyses of receivers' abilities to perceive various descriptor elements in previous experiments.

The "factor two" determinations were made primarily by arranging the descriptors such that a descriptor at any given level represents the sum of constituent descriptors at lower levels. The world is not a very crisp place and not all of its elements are amenable to hierarchical structuring. Certain violations of the "factor two" rule appear, therefore, throughout the proposed levels. Some of the more glaring violations were largely driven by the "factor one" determinations (i.e., the receivers' abilities to discern certain elements) enumerated above.

Thus, the visual information content as described by our fuzzy-set encoding ranges from the specific and detailed for level 10 to the unspecific and abstract for level 1. Please see Appendix A for a complete list of fuzzy set elements and their associated levels.

4.2 Analysis

Using the data from the static target set in the target-dependency experiment (see Section IV), we correlated the *post hoc* scores and the blind ranks with the content in each of the fuzzy set levels. Figure 19 shows this correlation only for those trials that demonstrated clear evidence for AC (i.e., scores ≥ 4 on the *post hoc* scale shown in Table 3 on page 21). The blind ranking appeared to be most sensitive to the elements in level 5. This is expected since level 5 contains complete visual elements, which are likely to be those that allow differentiation among targets. For example, *town, island, river, coastline,* are representative of the elements in this level. Most of the other positive correlations levels appear in the abstract levels, which contain elements of texture, color, and ambience.

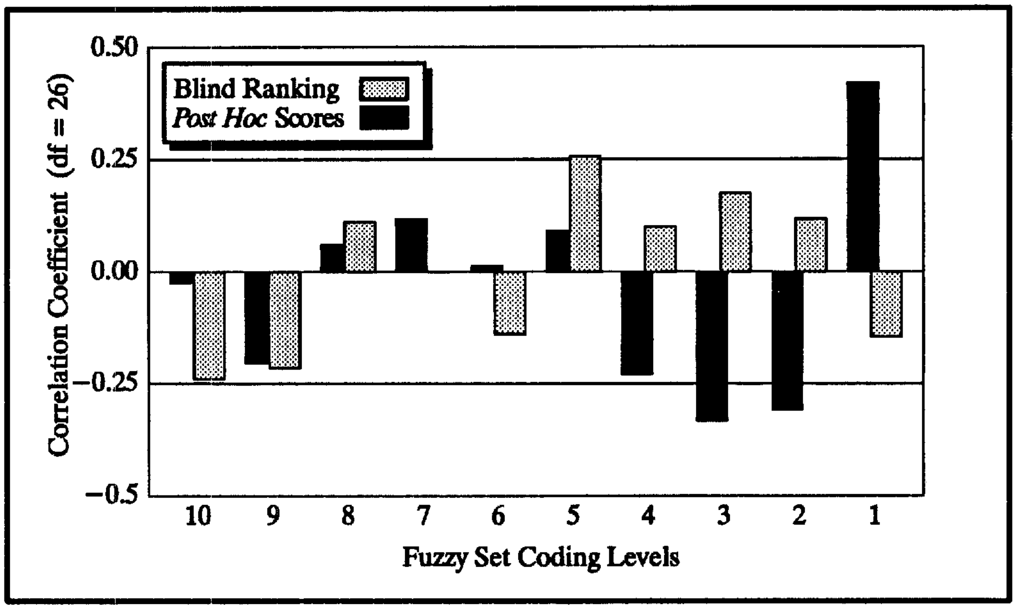


Figure 19. Correlation: Levels of Visual Complexity with *Post Hoc* Ratings and Blind Rankings for *Post Hoc* Scores Greater than Three (i.e., evidence for AC)

The interpretation of the correlations for the *post hoc* scores is less clear. The single strong positive correlation occurs with simple geometric elements in level 1. Since many AC responses consist of simple drawings, perhaps an analyst is drawn to these elements in the target while assigning scores. The negative correlations for levels 2-4 imply that most of the incorrect aspects of the response appeared in these levels. The elements in levels 2-4 include more complex geometries than in level 1 and more of those elements allowed discrimination in blind ranking.

We also computed the correlation for all 100 trials regardless of *post hoc* rating. The results are shown in Figure 20. One striking feature is the complete opposite correlation between blind ranks and *post hoc* scores. For example, level 10, the most specific and detailed, showed strong positive correlation for *post hoc* scores but a strong negative correlation for blind ranking. Thus, it appears that analysts were most sensitive to detailed visual elements in assigning *post hoc* scores, but were more likely to find these elements in decoy targets in blind ranking. This is precisely what is expected since a positive correlation with *post hoc* scores would include low scores for specifics that don't match.

Another striking feature in Figure 20 is that level 5 contains the elements that are best for discrimination in blind ranking. This same correlation was seen using only the data that indicated strong *post hoc* evidence for AC.

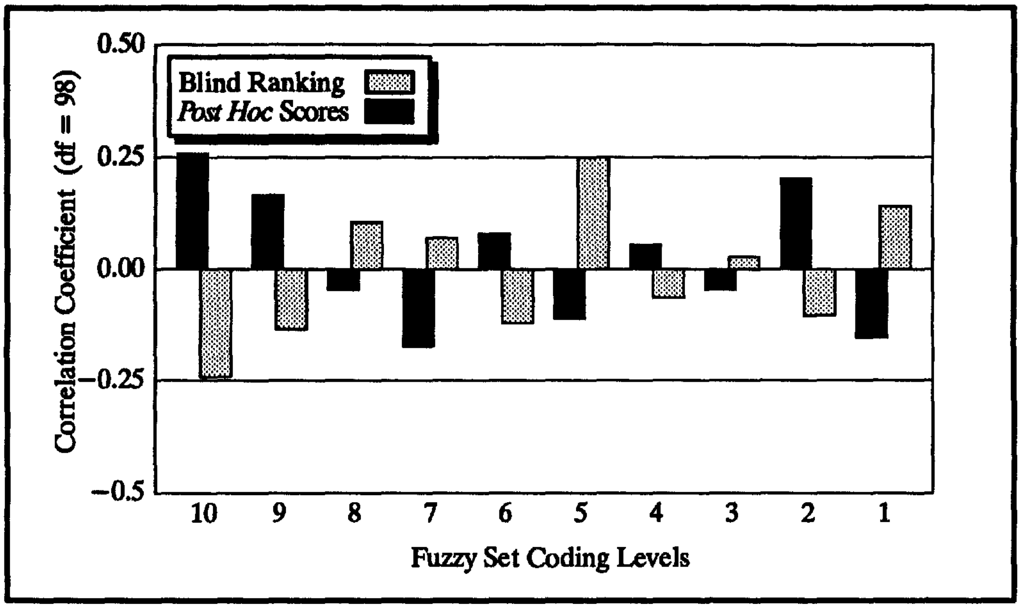


Figure 20. Correlation: Levels of Visual Complexity with *Post Hoc* Ratings and Blind Rankings for all *Post Hoc* Scores

4.3 Conclusion

Generally, elements that assist in a *post hoc* analysis are not the same elements that assist in blind ranking. Fuzzy set elements, which are generally image specific, are most sensitive in blind rank analysis, but specific visual elements are best for *post hoc*. These conclusions are based upon on set of 100 AC trials. It is currently unknown the degree to which they will generalize.

5. Empirical Training Overview

This section constitutes the final report on SOW item 6.3.3.1. The following discussion has been primarily provided by Professor D. Bem of the Psychology department of Cornell University.

5.1 Overview

We have examined a stimulus-response training method, which has been in use for a number of years.[42] Generally, this method assumes that internal visual imagery is a strong source of noise, at least for beginning receivers. The training method is highly focused on the structure of the response as an attempt to limit imagery. Not unlike a word association test, a receiver is asked to respond, as quickly as possible, to a stimulus such as the word "target." By refraining from a long introspection time, it is hoped that internal imagery does not have time to interfere with the AC "signal."

The training method requires that the structure of the response change as a student advances through a series of discrete stages. The stages represent access to increasing information about the target material. For example, Stage I consists primarily of large scale generalities about a site, such as mountains and cities, whereas Stage VI consists of specific analytic details involving relationships among the response elements.

5.2 Analysis

Most of the concepts outlined in this training method have not been individually tested under laboratory conditions. The method, however, has been used "successfully" in that individuals who have been trained by it produce stable and robust evidence of an AC ability (i.e., effect sizes of the order of 0.4). At this time, it is difficult to ascertain what elements, if any, are responsible for this observation.

Successful AC involves two basic steps:

(1) Obtaining the information

(2) "Transducing" or communicating the information so that it can be evaluated or acted upon

Only the first step involves AC, and we know very little about its intrinsic properties. In contrast, we have a number of reasonable hypotheses about what facilitates or hinders the second step. In fact, virtually all the specific procedures in this training method are directed toward facilitating this second step.

This training method has naturally evolved over the years so that the method has been optimized by the performance of a particular set of "star" receivers. This group, however, is highly selected, quite small, and may well be unrepresentative of a larger population of potentially successful receivers. As a result, this method is probably too narrow in the sense that it may be excluding many potential receivers who would be successful at obtaining AC information (i.e., step 1) but who cannot overcome a number of arbitrary and unnecessary obstacles to their transducing it accurately (i.e., step 2).

For example, the "star" receivers may do better at transducing visually, by drawing, than individuals who can communicate better verbally. The successes that have led us to give more weight to the drawings than to the verbal material might be an artifact of the transducing styles of the "stars" and not an inherent property of an AC ability.

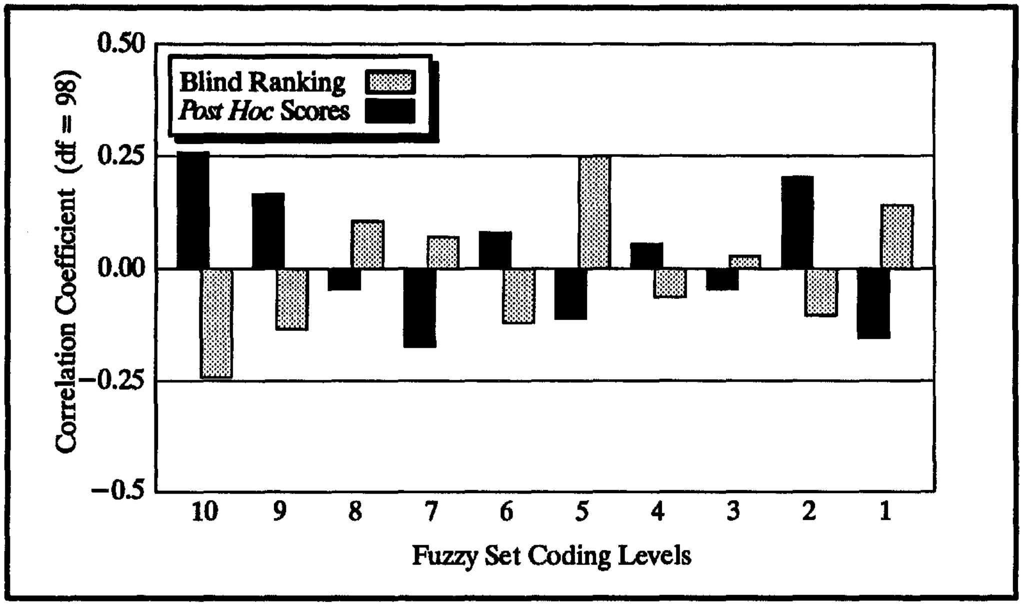
The research on individual differences also appears to tap differences in transducing skills. For example, meta-analysis shows that extroverts typically outperform introverts on specific AC tasks; however, these tasks involved considerable interaction with an experimenter or a sender. Yet, in other AC tasks, the opposite has been observed. Likely what is being observed is a preference style for a particular protocol that supports an individual's transducing proclivity. An ideal training method would recognize these types of individual differences in reporting.

For training purposes, providing intermediate feedback is certainly problematical. The training methodology calls for prescribed responses by a training monitor to various aspects of the student's response. There is substantial evidence to suggest that this is counterproductive. In reviewing 345 studies, Rosenthal and Rubin have shown that interpersonal expectancy effects, under certain circumstances, are extremely robust in behavioral research. That is, we communicate our expectations and other information to one another by non-verbal means, and, occasionally, this can be the primary mode of communication.[43] If the trainer is knowledgeable about the target material while in the training session, the implication is that the student may be recognizing non-verbal clues rather than aspects of AC. Minimally, what exactly the student has learned is indeterminate.

5.3 Suggested Modifications

In this section we describe a possible way to expand this training methodology, while still retaining most of the current procedure. In particular, we emphasize the stimulus-response format to avoid noise. The following is an outline of the suggested modification.

(1) Use the word "target" as a prompt, and let the receiver sketch anything that comes to mind. The receiver should have the opportunity to "pass" or draw nothing. In addition he or she should be



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(1) Use the word "target" as a prompt, and let the receiver sketch anything that comes to mind. The receiver should have the opportunity to "pass" or draw nothing. In addition he or she should be

explicitly told that it is not considered undesirable to pass, but it simply reflects a stylistic preference for ways of communicating.

(2) The receiver now generates any adjectives or terms that occur spontaneously. Passes are also allowed.

(3) The receiver is now prompted with a set of Semantic Differential Scales—bipolar dimensions—and asked to respond verbally in a stimulus-response fashion. For example, the trainer might say "hot-cold" and the viewer might respond with "warm, cold, stiff, sauna, or pass." In other words, the trainer gives the dimension and the receiver gives any response at all.

(4) The receiver may now supply any additional dimension and/or terms that occur to him or her. This is essentially a repeat of step 1, recognizing that step 3 may have promoted new material.

(5) The session ends after a number of repeats of steps 1-4 and with a final integration of drawn and verbal material.

5.4 Discussion

Note that this sequence goes from unstructured to structured responses, with no pressure to use any procedure that seems uncomfortable. For example, if the receiver feels distracted by having to use pen and paper, he or she should have the option not to do so; the monitor could tape-record the session, for example.

Step 3 is modeled on word association techniques. There are several possibilities for the scales. We could:

- Use our visual fuzzy set elements.
- Select dimensions from previous work on the Semantic Differential.
- Conduct a preliminary study on a subset of targets that are displayed to receivers, and allow the receivers to generate dimensions that are tailored specifically by them for those targets.
- Let each receiver construct his or her own impressionistic vocabulary by serving in a session described above. Then present these individualized dimensions as stimuli in the subsequent AC sessions.

The dimension of the presented stimuli should not be confined to physical/visual features of targets but should range widely over affective and impressionistic dimensions as well (e.g., *kind-cruel, soft-hard, good-bad*). The Semantic Differential was originally developed to tap *affective* or *connotative* meaning, and factor analyses uncovered three orthoginal dimensions that appear to have cross-cultural universality:

(1) An evaluative dimension (e.g., *good-bad*)
(2) An activity dimension (e.g., *active-passive*)
(3) A potency dimension (e.g., *strong-weak*)

An effective procedure should use scales from all three factors.

It is possible to use prompts other than those of bipolar dimension. For example,the prompt could be the name of a sensory modality like *smell* or *odor* to which a receiver could respond "dank, bakery, acidic, or pass." Or the prompt could be *mood* or *emotion* and the response could be "sad, tranquil, agitated, or pass." Cross-cultural research reveals that six dimensions of affect appear to be universal: happy, sad, anger, fear, disgust, and surprise. These might be pertinent for some target pools.

We have stressed cross-cultural dimensions here to approach AC from the viewpoint of evolution. If some kind of AC is functionally adaptive for the species, what would its properties be? Affectively relevant information is the most likely to be accessed in AC-related ways, and universal categories of affective description have the best chance for transducing such information. In contrast, we speculate that the vocabulary for describing visually descriptive features of locations is much more derivative and further removed from primordial experience.

Once a descriptive set of dimensions has been decided upon for a particular target set, preliminary sessions with student receivers can be used to train them in the use of the dimensions. This can be accomplished by using practice targets on which there is consensus on the applicability of the dimensions to each photograph. If dimensions are tailored to each individual, then these preliminary sessions are those in which the student receiver constructs his or her dimensions rather than learning a universal set.

5.5 Conclusion

We have analyzed one existing AC training methodology and have provided a schematic outline of modifications that might improve the method by generalizing it. We emphasize that this suggestion is in our 5-year research plan, which was developed under this program. It is important to realize that many different approaches should be explored. The one presented here represents only a modest modification of the existing method.

6. A Potential New Training Method

This section constitutes the final report on SOW item 6.3.3.2.

We have designed a potential new training methodology that is based upon subliminal perception.

6.1 Background

Preconscious processing of sensory information may be responsible for much of the perceptual information that reaches conscious awareness. A trivial example is the processing of the left and right two-dimensional retinal images into a single three-dimensional cyclopean percept. Because the eyes view the world from different viewpoints, the two retinal images are not superimposable, and frequently contain different information about the external environment. In those abnormal instances where both retinal images reach conscious awareness, the receiver perceives diplopic images of the external environment, that is, he has double vision. The observations that the cyclopean image is not retinotopic for either eye and that the cyclopean image is created without conscious effort are strong support for preconscious processing of sensory information.

A more significant example is provided by the Poetzl effect,[44] in which an unperceived stimulus is capable of evoking subsequent memories of having perceived the stimulus. Very often, the memories are distorted, but contain spatial, chromatic, textural, temporal, and contextual elements of the previously unperceived stimulus. This effect provides evidence of preconscious processing of not only the unperceived stimulus, but of its primitives in several domains, such as color.

The most compelling evidence for preconscious processing is provided by a body of research commonly known as blindsight.[45] Blindsight can occur when anatomical brain structures that are crucial to visual perception, such as the striatal cortex, have been destroyed, but the remainder of the visual system is intact. Under these conditions, any visual stimulus that falls on an area of the retina that projects to the destroyed area of the striate cortex cannot reach perceptual awareness. A person with this condition is blind in this area of the visual field. A large body of evidence, however, demonstrates that persons with this condition can respond to visual stimuli, even though they cannot see them. Furthermore, persons with blindsight can make visual discriminations, for example, of form and color, without perceiving the form or color of the stimuli. Blindsight, then, is a compelling example of preconscious, or perhaps extra-conscious processing.

Other evidence of preconscious processing can be found by comparing the sensory and perceptual thresholds. The sensory threshold can be determined physiologically by measuring the amplitude of a stimulus that elicits an identifiable signal in a receptor system, for example, a change in the firing rate of a sensory neuron. The perceptual threshold can be defined as that amplitude of the same stimulus that elicits a response indicating that the stimulus has been detected. It is a well-known phenomenon that the sensory and perceptual threshold can differ markedly.[46,47] Thus, between the sensory and perceptual thresholds, the receiver is processing information that is below the perceptual threshold, that is, preconscious processing.

The question of interest here is whether the perceptual threshold can be reduced so that it is closer to the physiological threshold. Several studies suggest conditions under which the perceptual threshold can be lowered to more closely approximate the sensory threshold. For example, changing the emotional content of the stimuli or the emotional state of the receiver has been shown to affect the perceptual thresholds for subliminal stimuli.[48,49] Essentially, reducing the emotional state of the receiver or elevating the emotional content of the stimulus reduces the perceptual threshold.

The question can now be refined to ask whether the perceptual threshold can be reduced through training. Couched in terms of signal detection theory, the question can be posed: Can the receiver's threshold be changed through training so that the receiver can detect a signal at a lower signal-to-noise ratio?

Here, again, the answer is yes. Detection thresholds have been found to respond to training protocols that use feedback on repeated trials to elevate sensitivity to previously unperceived visual cues.[50,51,52] We suggest that the detection threshold be changed through a program of repeated feedback.

6.2 A Suggested Experiment

This suggested experiment has a two-fold purpose. The first is to assess the effects of training protocols on the detection thresholds for subliminal visual stimuli. The second is to examine whether those receivers whose thresholds were lowered by training perform better on AC tasks than receivers who have not been through the training. By using threshold-lowering training protocols, we will attempt to increase the sensitivity of receivers to subliminal visual stimuli so that following training, stimuli that had been subliminal will be supraliminal. We will then determine whether there is a parallel increase in sensitivity to AC stimuli.

Specifically, we suggest that receivers first be randomly assigned to a subliminal-training group and a sham-training group. No receiver will be informed of his or her status until both the training and remote-viewing portions of the study have been completed.

Each receiver in both groups will be shown a series of target images that are presented tachistoscopically for approximately 10 milliseconds, alternating with a 5-second presentation of a masking stimulus. All target images will be below the receiver's detection threshold, that is, they will be subliminal. Interspersed randomly among the subliminal stimuli will be an equal number of blank trials in which no target image is presented during the 10-millisecond presentation.

Immediately following each presentation of either the blank or target stimulus, the receiver will respond by pressing a button indicating either that he was aware that a target was presented or that he was unaware. Essentially, the receiver's task will be to report whether a target was presented. After each response, the receiver will receive feedback about whether his response was correct or incorrect. The experimental paradigm is shown in Figure 21.

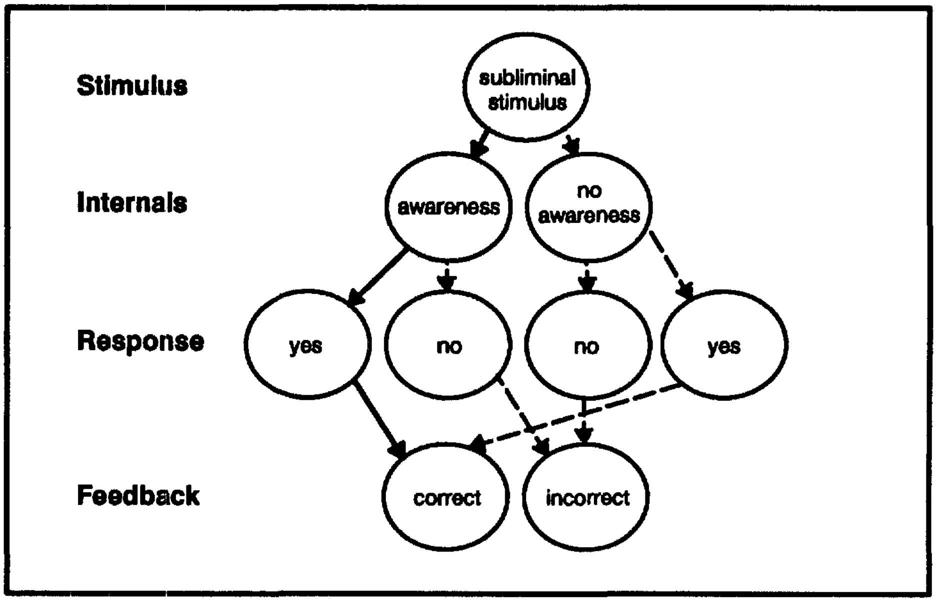

Figure 21. Experimental Paradigm for Training.

Receivers in the subliminal-training group will receive truthful feedback about their performance, whereas receivers in the sham-training group will receive random feedback. Because all stimuli will be subliminal, sham-training receivers should not be able to detect that the feedback is uncorrelated with the stimuli.

Feedback to the subliminal-training receivers is expected to reinforce the pathways identified by bold arrows in Figure 21. The proportion of "yes" responses under blank-trials conditions (i.e., sham-training) will be used to estimate the guessing rate.

Several hundred trials will be run, and cumulative performance measures, in terms of percentage of correct responses, will be calculated for each of the sham-trained and subliminally-trained receivers. Receivers from both groups will participate in a blind study of remote-viewing performance.

X. GLOSSARY

Not all the terms defined below are germane to this report, 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.
- Agent—An individual who attempts to influence a target system.
- Analyst—An individual who provides a quantitative measure of AC.
- Anomalous Perturbation (AP)—A form of interaction with matter in which all known physical mechanisms are absent.
- Feedback—After a response has been secured, information about the intended target is displayed to the receiver.
- Monitor—An individual who monitors an AC session to facilitate data collection.
- Protocol—A template for conducting a structured data collection session.
- Receiver—An individual who attempts to perceive and report information about a target.
- Response—Material that is produced during an AC session in response to the intended target.
- Sender/Beacon—An individual who, while receiving direct sensorial stimuli from an intended target, acts as a putative transmitter to the receiver.
- Session—A time period during which AC data are collected.
- Specialty—A given receiver's ability to be particularly successful with a given class of targets (e.g., people as opposed to buildings).
- 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).

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APPENDIX A

Target Elements for the Fuzzy Set Representation of AC Targets

APPENDIX B

The Ganzfeld Novice: Four Predictors of Initial ESP Performance

The Ganzfeld Novice: Four Predictors of Initial ESP Performance

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Abstract: This report updates earlier studies examining characteristics of successful novice ganzfeld participants. A new study comprising Novice Series 103-105 in the PRL automated ganzfeld study (Honorton, Berger, Varvoglis, Quant, Derr, Schechter, & Ferrari, 1990) is compared with a previous PRL study (Honorton & Schechter, 1987) and an independent study reported by the FRNM research team (Broughton, Kanthamani, & Khilji, in press). ESP ganzfeld performance is examined in relation to four predictors: reported personal psi experiences, Myers-Briggs Feeling/Perception, prior (nonganzfeld) psi testing, and involvement with mental disciplines such as meditiation.

One of the goals of the PRL automated ganzfeld research was to identify characteristics associated with successful ESP ganzfeld performance by previously inexperienced participants (novices). Two hundred and six participants each contributed to one of five novice series in the PRL automated ganzfeld project. (See Honorton, Berger, Varvoglis, Quant, Derr, Schechter, & Ferrari [1990] for details of experimental procedures and overall results.) Most participants completed Form F of the Myers-Briggs Type Indicator (MBTI; Briggs & Myers, 1957) and a 55-item demographic survey (Participant Information Form, PIF).

Three previous reports have already described aspects of the PRL-novice research. The relationship between novice ESP ganzfeld performance and extraversion was presented by Honorton, Ferrari, & Bem (in press). Schlitz & Honorton (1992) described a subset of the PRL novice data involving performing artists from The Juilliard School. At the 1986 PA Convention, Honorton and Schechter (1987) presented an exploratory analysis of performance correlates for the first two PRL novice series (Series 101-102; hereafter designated PRL-1), suggesting that initial ganzfeld ESP performance was positively and significantly related to self-reports of personal psi experiences, Feeling/Perception (FP) preferences on the MBTI, and prior participation in nonganzfeld psi experiments. A positive but nonsignificant tendency for better performance among participants reporting involvement with mental disciplines such as meditation was also found.

Broughton, Kanthamani, & Khilji (in press) successfully replicated the ESP/FP finding in an independent study at FRNM. In this paper, the PRL-1 findings will be compared with those in the later PRL novices series (Series 103-105; hereafter designated PRL-2) and the FRNM series to estimate the overall magnitude and consistency of the four predictors.

Following presentation of the Honorton & Schechter report, an effort was made to obtain Myers-Briggs data from PRL-1 participants who had not originally taken the MBTI, and ten participants kindly cooperated. Their data are included in the PRL-1 totals in this report. The PRL-1 findings summarized in this paper also reflect corrections for a number of data entry errors in the Honorton & Schechter (1987) report that were discovered during a data audit of the entire PRL automated ganzfeld database prior to publication of Honorton, et al., (1990).

The PRL novices included 121 women and 85 men (total N = 206). PIF data was available for 195 and MBTI data was available for 190 subjects. As can be seen from Table 1, these participants

Table 1. Descriptive Statistics for PRL Novices

	Age	Formal Education (years)	EI	SN	TF	JP	Belief in Psi (1-7)	Reported Psi Experiences (0-4)	Prior Psi Testing (Not Ganzfeld)
Mean	36.63	15.42	101.51	127.92	103.78	110.67	6.22	2.16	*N* = 32
SD	12.29	2.02	25.15	17.64	22.75	26.41	0.99	1.16	
Median	36	16	99	132	106	113	7	2	

Table note: Scores on MBTI scales increase in the direction of the second letter (e.g., EI scores below 100 signify extraversion while those above 100 signify introversion).

tended to be mature, moderately well educated, and, perhaps most prominently, strong believers in psi. Of the MBTI scales, only the SN (Sensing/Intuition) MBTI Scale was unusual: PRL novices tended strongly toward the Intuition side of the scale. A recent reevaluation of the MBTI scales in terms of the five-factor model of personality indicates that the SN scale is highly correlated with openness to experience (McRae & Costa, 1989). The two PRL studies differed significantly on responses to four PIF items: PRL-2 subjects were younger, reported fewer personal psi experiences, a lower frequency of coincidences, and, curiously, stronger belief in luck than those in PRL-1. These differences, with the exception of luck, are due to the Juilliard students in PRL-2. The Juilliard students were much younger and rated themselves significantly lower on belief in psi and personal psi experiences than the PRL population (Schlitz & Honorton, 1992, p. 91).

Differences Between PRL and FRNM Novices

PIF data were available for 108 of the 120 FRNM novices. The PRL and FRNM novices also differed significantly in four areas. PRL novices were significantly older ($t = 7.15$, 303 *df*, $p < 10^{-6}$, $r = .38$) and had a significantly higher mean on the MBTI SN Scale than their FRNM counterparts ($t = 2.09$, 290 *df*, $p = .037$, two-tailed). The incidence of reported personal psi experiences was significantly lower for the FRNM novices than for their PRL counterparts (Overall-adjusted Fisher exact $p = .0163$, $phi = .12$ [Overall, Rhoades, & Starbuck, 1987]) as was involvement in mental disciplines (Overall-adjusted Fisher exact $p = .00018$, $phi = .20$).

Psi Performance

Table 2 summarizes novice psi performance in the three studies. (In this report, all *p*-values are one-tailed unless otherwise noted. ESP hit rates are tested using exact binomial probabilities with $p = .25$ and $q = .75$. *Z*-scores, calculated from the inverse normal function, are provided to facilitate meta-analytic comparisons.)

Thirty percent of the PRL-1 novices correctly identified their targets ($N = 100$, $p = .15$, $z = 1.04$). The effect size (Cohen's *h*; Cohen, 1977) was .11, with a 95% confidence interval (CI) from 22% to 38%. In PRL-2, 35% of the novices were successful ($N = 106$, $p = .015$, $z = 2.18$, $h = .22$, 95% CI from 27% to 43%). Hits were obtained by 28% of the FRNM novices ($N = 120$, $p = .23$, $z =$

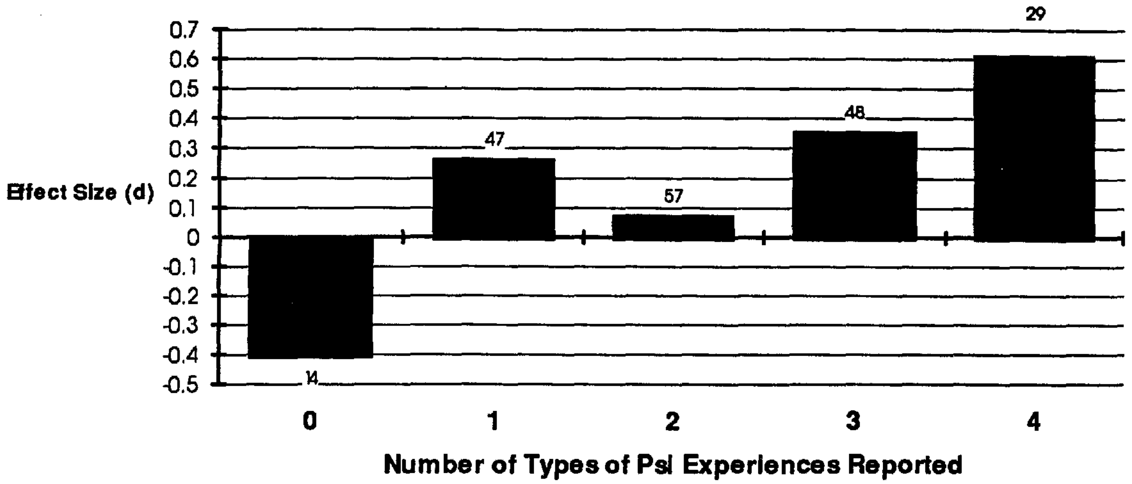
Table 2. Ganzfeld Novice ESP Performance in Two Laboratories

	N	% Hits	95% CI From	95% CI To	Effect size (*h*)	*z*	*p*
PRL-1	100	30	22	38	.11	1.04	.150
PRL-2	106	35	27	43	.22	2.18	.015
FRNM	120	28	21	36	.08	0.75	.23
Combined	326	31	26	36	.13	2.25	.012

Homogeneity of effect sizes: $\chi^2 = 2.39$, 2 *df*, $p = .30$

Table notes. Percent hits and confidence estimates are rounded to nearest percentage point. Combined effect size and Stouffer z are weighted by study sample size.

Figure 1. Ganzfeld Performance in Relation to Reported Psi Experiences



0.75, h = .08, 95% CI from 21% to 36%). The three studies combined yield a success rate of 31% (N = 326, p = .012, z = 2.25, h = .13, 95% CI from 26% to 36%). The effect sizes of the three studies are quite consistent (χ^2 = 2.39, 2 df, p = .30).

Reported Personal Psi Experiences

Following standard definitions of the four basic psi types, PIF item 14 asks "If you have had experiences which you thought involved psi, which of the following do you feel you have experienced (please check)." One point was given for each of the checked items (telepathy, clairvoyance, precognition, psychokinesis) and their sum constituted the psi experiences predictor.

Honorton and Schechter (1987) found a significant positive correlation between the number of types of psi experiences and psi ganzfeld

Table 3. Ganzfeld Psi Performance in Relation to An Alternate Measure of Reported Psi Experiences

Personal Psi Experiences?	Study	*N* Trials	% Hits	95% CI From	95% CI To	Effect Size (*h*)	*z*	*p*
	PRL-1	7	14	1	55	-.27	-1.11	.867
"None"	PRL-2	7	29	5	66	.08	-0.14	.555
	FRNM	17	29	12	54	.10	0.19	.426
	Combined	31	26	11	41	.01	-0.28	.61
	PRL-1	84	33	24	43	.18	1.61	.054
"Some"	PRL-2	97	36	27	45	.24	2.33	.010
	FRNM	91	31	22	40	.13	1.14	.126
	Combined	272	33	28	39	.19	2.96	.0015
Difference in proportions ("None" vs. "Some")							0.85	.197

Table notes. Percent hits and confidence estimates are rounded to nearest percentage point. Combined effect sizes and Stouffer's zs are weighted by study sample sizes. Confidence intervals for subsets with $N \leq 30$ are based on Blyth & Still (1983). None/Some difference is based on a z-test for binomial proportions using the combined (sample size weighted) estimates for each group.

performance (session *z*-scores but *not* direct hits) for participants in PRL-1. Recast as a one-way ANOVA using linear contrasts (Rosenthal & Rosnow, 1985), $F = 7.41$, 1/86 *df*, $p = .0039$ ($r = .28$). This relationship was replicated in PRL-2 ($F = 2.86$, 1/99 *df*, $p = .047$, $r = .17$). As described earlier, the Juilliard students, who contributed to the later study, reported significantly fewer types of personal psi experiences. When they are excluded from the PRL-2 analysis, the relationship between psi performance and psi experiences is nearly identical to that obtained in PRL-1 ($F = 6.29$, 1/79 *df*, $p = .007$, $r = .27$).

Combining the two PRL studies gives $F = 9.37$, 1/190 *df*, $p = .0015$, $r = .24$. Figure 1 shows the relationship between number of types of psi experiences reported and ganzfeld effect size (Cohen's *d*; Cohen, 1977).

Due to their rewording of the relevant PIF question in the FRNM study, Broughton, et al., could not perform the same analysis on their data. Instead, they reported a modified analysis between self-reports of psi experiences (coded as "none" or "some") and direct hits. FRNM novices reporting "some" personal psi experiences were nonsignificantly more successful than those reporting "none." Since the FRNM report does not provide *z*-scores, Table 3 summarizes all three studies using the FRNM psi experience definition as the predictor and direct hits as the outcome measure. The combined difference between participants who did and did not report personal psi experiences is not significant in this analysis, but significant ESP performance was only obtained by those who reported psi experiences ($N = 272$, 33% hits, $p = .0015$, $z = 2.96$, $h = .19$).

The stronger association in the PRL data between number of types of personal psi experiences and session *z*-scores (rather than direct hits) indicates that persons who believe they have had a variety of psi experiences are more adept at identifying partial correspondences between their ganzfeld experience and targets in the judging pool. Further research is needed to determine whether this is better explained by motivational or cognitive factors. Perhaps those who report an abundance of psi experiences, motivated by a need to validate their personal experiences, expend more effort to find correspondences when judging their ganzfeld mentation against the target pool. If so, there should be a positive relationship between abundance of types of personal psi experiences and the amount of time taken for judging. This could be tested by measuring judging time in future studies. An alternative cognitive model might suggest that abundance of reported psi experiences correlates with general pattern recognition ability, which could be tested by giving participants a variety on nonpsi pattern recognition tasks.

Prior Psi Testing

PIF item 19 asks, "Have you ever participated in formal laboratory testing of psi phenomena [Yes/No]?" By definition, none of the novices had previous psi ganzfeld experience. While most of

Table 4. Summary of Prior Testing

Prior Psi Testing?	Study	N Trials	% Hits	95% CI From	95% CI To	Effect Size (h)	z	p
	PRL-1	72	26	16	36	.03	0.16	.437
No Prior Psi Testing	PRL-2	92	32	23	40	.15	1.31	.0948
	FRNM	94	31	22	40	.13	1.18	.1182
	Combined	258	30	25	35	.11	1.62	.053
	PRL-1	20	50	29	71	.52	2.20	.0139
Prior Psi Testing	PRL-2	12	67	34	83	.86	2.77	.0028
	FRNM	14	29	10	58	.05	0.05	.4787
	Combined	46	48	35	60	.47	2.87	.0021
Difference in proportions (Prior vs. No Prior Testing):							2.35	.0094

Table notes. Percent hits and confidence estimates are rounded to nearest percentage point. Combined effect sizes and Stouffer's zs are weighted by study sample sizes. Confidence intervals for subsets with $N \leq 30$ are based on Blyth & Still (1983). Prior/No Prior Testing difference is based on a z-test for binomial proportions using the combined (sample size weighted) estimates for each group.

them had not been previously involved in formal psi research of any kind, approximately 16% of the PRL novices and 13% of FRNM novices had participated in other types of psi research. In PRL-1 a hit rate of 50% was achieved by novices who had previously participated in other, nonganzfeld, psi experiments (N = 20, p = .014, z = 2.20, h = .52), while only 26% of those with no prior psi testing experience had hits (N = 72, 19 hits and 53 misses, p = .437, z = 0.16, h = .03). The distribution of hits and misses in relation to prior testing was significant: Overall-adjusted Fisher exact test (p = .024, *phi* = .21). In PRL-2, 67% of those with previous testing experience had hits (N = 12, p = .0028, z = 2.77, h = .86) as did 32% of subjects with no prior testing history (N = 92, p = .095, z = 1.31, h = .15). The Overall-adjusted Fisher test of the distribution of hits and misses was significant (p = .02, *phi* = .23).

This effect was not replicated in the FRNM study, which showed a slight reversal of the trend: hits were obtained by 29% of subjects with prior testing (N = 14, p = .479, z = 1.05, h = .08) and by 31% of those with no prior testing (N = 94, p = .118, z = 1.18, h = .13); Overall-adjusted Fisher p = .543 (*phi* = -.01). The overall effect of prior testing is significant, though clearly further research will be needed to assess the cross-laboratory generality of this finding. (See Table 4.) The mean weighted *phi* is .14 (95% CI from .02 to .25).

Myers-Briggs Feeling-Perception

Following MBTI convention, participants were classified as FP if their continuous scores on the TF and JP Scales were both above 100. A recent reevaluation of the MBTI in terms of the five-factor model of personality (McCrae & Costa, 1989) indicates that the MBTI TF Scale correlates positively with Agreeableness. JP correlates negatively with Conscientiousness (i.e., orderliness) and positively with Openness to Experience.

In PRL-1, 50% of the MBTI FP participants obtained hits (p = .00057, z = 3.25, h = .52) compared to 18% of those classified non-FP (N = 44, p = .892, z = -1.24, h = -.17). The Overall-adjusted Fisher exact p = .001 (*phi* = .34). In PRL-2, the FP success rate was 36% (N = 44, p = .075, z = 1.44, h = .23) and 35% of the nonFP subjects were successful (N = 60, p = .054, z = 1.61, h = .22). The Overall-adjusted Fisher exact p = .472 (*phi* = .01).

In the FRNM series, 40% of the FP subjects had hits (N = 42, p = .02, z = 2.06, h = .33), compared to 25% for the nonFP subjects (N = 60, p = .5, z = 0.00, h = .00). The Overall-adjusted Fisher exact p = .0499 (*phi* = .16).

Table 5 summarizes the results across all three studies. The FP subjects show significant performance (N = 127, p = .000064, z = 3.83, h = .38). The 95% confidence interval for the mean success rate of 42% is from 34% to 49%. NonFP show nonsignificant overall performance, with a hit rate of 27% (N = 164, p = .33, z = 0.44, h = .035); the 95% CI is from 20% to 34%. The difference in overall success rates between FP and nonFP subjects is also significant (z = 2.69, p = .0036). Using meta-analytic techniques for combining correlations (Hedges and Olkin, 1985), the

Table 5. MBTI Feeling/Perception (FP)

FP?	Study	N	% hits	95% CI From	95% CI To	Effect size (h)	z	p
Yes	PRL-1	40	50	37	64	.52	3.25	.00057
	PRL-2	45	36	23	48	.23	1.44	.075
	FRNM	42	40	27	54	.33	2.06	.02
	Combined	127	42	34	49	.38	3.83	.000064
No	PRL-1	44	18	5	31	-.17	-1.24	.892
	PRL-2	60	35	24	46	.22	1.61	.054
	FRNM	60	25	14	36	.00	0.00	.500
	Combined	164	27	20	34	.035	0.44	.33
Difference in proportions (Combined FP vs No FP)							2.69	.0036

Table notes. Percent hits and confidence estimates are rounded to nearest percentage point. Combined effect sizes and Stouffer's zs are weighted by study sample sizes. FP/no FP difference is based on a z-test for binomial proportions using the combined (sample size weighted) estimates for each group.

mean weighted *phi* is .16 (95% CI from .05 to .27).

Mental Disciplines

PIF item 28 asks, "Have you ever practiced any form of mental discipline, e.g., meditation, biofeedback, hypnosis, relaxation exercises [Yes/No]." In PRL-1, hits were obtained by 36% of those reporting some experience involving mental disciplines ($N = 72$, $p = .024$, $z = 1.98$, $h = .24$) and by 16% of those with no involvement with mental disciplines ($N = 19$, $p = .89$, $z = -1.22$, $h = -.23$). In PRL-2, hits were obtained by 33% of participants with mental disciplines experience ($N = 83$, $p = .075$, $z = 1.44$, $h = .17$) and by 48% of the nonpractitioners ($N = 21$, $p = .021$, $z = 2.04$, $h = .48$); the latter outcome is largely due to the Juilliard nonpractitioners who had a success rate of 71% ($N = 7$, $p = .0129$, $z = 2.23$, $h = .97$). The distribution of hits in relation to mental disciplines for the Juilliard students shows a nearly significant reversal of the PRL-1 pattern (Overall-adjusted Fisher exact $p = .091$, $phi = -.30$).

In the FRNM study, practitioners had a 34% hit rate ($N = 65$, $p = .07$, $z = 1.48$, $h = .19$), compared to 26% for the nonpractitioners ($N = 43$, $p = .477$, $z = .06$, $h = .01$).

Table 6 summarize the three studies. Thirty-four percent of the practitioners were successful overall ($N = 220$, $p = .0025$, $z = 2.81$, $h = .20$, 95% CI from 28% to 40%), compared to 28% of the nonpractitioners ($N = 83$, $p = .37$, $z = 0.33$, $h = .07$, 95% CI from 20% to 38%). The difference between practitioners and nonpractitioners is nonsignificant ($z = 0.96$, $p = .168$, $phi = .06$). When the Juilliard students are excluded, the overall difference increases to $z = 1.45$, $p = .086$, $phi = .09$.

Combined-Predictor Models

In this section we examine the combined effects of the predictors. There are significant intercorrelations among three of the predictors in the combined PRL data: reported psi experiences, FP, and mental disciplines. The strongest correlation is between FP and psi experiences ($r = .226$, 185 *df*, $p = .002$). The correlation between FP and involvement with mental disciplines is .184 ($p = .012$). Mental disciplines and psi experiences show a correlation of .179 (193 *df*, $p = .012$). The fourth predictor, prior psi testing, correlates positively but nonsignificantly with psi experiences ($r = .106$, 193 *df*, $p = .139$) and with mental disciplines ($r = .088$, 193 *df*, $p = .222$). Prior testing is negatively but nonsignificantly correlated with reported psi experiences ($r = -.101$, 185 *df*, $p = .169$). Since no prior predictions were made concerning the direction of relationships among the predictors, the cited *p*-values are two-tailed.

The Four-Predictor Model

Due to the small number of participants with

Table 6. Ganzfeld Psi Performance in Relation to Mental Disciplines

Mental disciplines?	Data Set	*N*	% Hits	95% CI From	95% CI To	Effect Size (*h*)	*z*	*p*
Nonpractioners	PRL-1	19	16	4	39	-.23	-1.22	.89
	PRL-2	21	48	28	70	.48	2.04	.021
	FRNM	43	26	13	38	.01	0.06	.48
	Combined	83	28	20	38	.07	0.33	.37
Practitioners	PRL-1	72	36	26	46	.24	1.98	.024
	PRL-2	83	33	23	42	.17	1.44	.075
	FRNM	65	34	23	44	.19	1.48	.07
	Combined	220	34	28	40	.20	2.81	.0025
Difference (Combined Yes vs. No)							0.96	.168

Table notes. Percent hits and confidence estimates are rounded to nearest percentage point. Combined effect sizes and Stouffer's zs are weighted by study sample sizes. Confidence intervals for subsets with $N \leq 30$ are based on Blyth & Still (1983). Yes/No difference is based on a z-test for binomial proportions using the combined (sample size weighted) estimates for each group.

Table 7. The Three Factor Model

Psi+FP+Mental Disciplines?	Study	N	% Hits	95% CI From	95% CI To	Effect Size (h)	z	p
	PRL-1	49	18	6	31	-.16	-1.26	.895
No	PRL-2	67	37	27	48	.27	2.12	.017
	FRNM	74	27	17	37	.05	0.29	.386
	Combined	190	28	20	38	.07	0.92	.179
	PRL-1	34	56	41	70	.64	3.67	.00012
Yes	PRL-2	37	32	19	46	.17	0.86	.194
	FRNM	28	43	26	62	.38	1.89	.029
	Combined	99	43	35	52	.39	3.64	.00014
Difference (Combined Yes vs. No)							2.64	.0041

Table notes. Percent hits and confidence estimates are rounded to nearest percentage point. Combined effect sizes and Stouffer's zs are weighted by study sample sizes. Confidence intervals for subsets with $N \leq 30$ are based on Blyth & Still (1983). Yes/No difference is based on a z-test for binomial proportions using the combined (sample size weighted) estimates for each group.

prior psi testing experience, only 15 participants satisfied the four-predictor model (reported psi experiences, FP, mental disciplines, and prior testing) in the three studies. Nevertheless, the results are rather striking. In PRL-1 hits were obtained by six of the seven participants satisfying all four factors (p = .0013, z = 3.00, h = 1.32). Three out of four were successful in PRL-2 (p =.0508, z = 1.64, h = 1.05). In the FRNM series, hits were obtained by two of the four participants satisfying all four factors. Combining across the three studies, 11 of the 15 participants correctly identified their targets (73% hits, weighted z = 3.35, p = .00041). The overall effect size (h weighted by sample size) is = 1.03.

The Three-Predictor Model

Due to the extremely small number of cases satisfying the four-predictor model, Honorton & Schechter (1987) and Broughton, et al., (in press) focused on a three-factor model, excluding prior psi testing. Combining the three studies, 99 participants satisfied the three-predictor model (reported psi experiences, FP, and involvement with mental disciplines). In PRL-1, 34 participants satisfied the three-factor model. They achieved a success rate of 56% (p = .00012, z = 3.67, h = .64) and the 95% CI is from 41% to 70%. An 18% success rate was obtained by the 49 PRL-1 participants not satisfying the three-factor model, but for whom data on all three factors is available (p = .895, z = -1.26, h = -.16, 95% CI from 6% to 31%). This pattern was slightly reversed in PRL-2 with a success rate of 32% for those satisfying the model (N = 37, p = .194, z = 0.86, 95% CI from 19% to 46%) and a 37% success rate for those who did not satisfy it (N = 67, p = .017, z = 2.12, h = .27, 95% CI from 27% to 48%). In the FRNM study, 28 participants satisfied the model with a success rate of 43% (p = .029, z = 1.89, h = .38, 95% CI from 26% to 62%). A success rate of 27% was obtained by the 74 FRNM participants who did not satisfy the model (p = .386, z = 0.29, h = .07, 95% CI from 17% to 37%).

Table 7 summarizes the results of all three studies. Overall, the three-factor model appears to show some promise. Altogether 99 novice participants in three studies satisfied the three-predictor model, with an overall success rate of 43% (z = 3.64, p = .00014, h = .39, 95% CI from 35% to 52%). The 191 participants not satisfying the model obtained a success rate of 28% (z = 0.92, p = .179, h = .07, 95% CI from 20% to 38%). The difference between the two groups is significant (z = 2.64, p = .0041) and the *phi* coefficient is .15.

Discussion

While none of the predictors individually differentiated successful versus unsuccessful performance in each of the three studies, significant hitting across all three studies was limited to participants meeting the criteria for each of the individual predictors. From a purely pragmatic point of view, if we were advising new ganzfeld investigators how to maximize the likelihood of successful psi ganzfeld performance in their studies, we would recommend that they recruit participants who conform to as many of these factors—plus extraversion (Honorton, Ferrari, & Bem, in press) —as possible.

More detailed and systematic refinement of the four predictors used in these studies would probably be more useful at this stage than further direct replications involving the current implementation. The PRL results using number of types of reported psi experiences as a predictor, for example, suggest that a more refined measure of participants' putative psi experiences might well be more effective. Such a measure might include items to assess the predominant mode, as well as type and frequency of the participants' reported psi experiences. This would enable investigators to test whether or not the modality of participants' personal psi experiences is systematically (and perhaps differentially) related to performance in different types of experimental task: for instance, whether those whose experiences are primarily imagery-driven are better ganzfeld performers than those whose experiences involve noncognitive impressions and vice versa for unconscious psi tasks such as remote physiological influences (e.g., Braud & Schlitz, 1992).

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APPENDIX C

Impact of the Sender in Ganzfeld Communication: Meta-Analysis and Power Estimates

Impact of the Sender in Ganzfeld Communication: Meta-Analysis and Power Estimates

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Abstract: This report provides a quantitative review of all available studies of information retrieval via real-time ganzfeld imaging techniques reported in the English-language parapsychological literature between 1974-1991. The review estimates the magnitude of the effect overall and as a function of target presentation conditions (presence or absence of a target observer or sender). The resulting estimates are used in a statistical power analysis to determine optimal sample sizes for maximising successful detection of ganzfeld communication in new studies.

Keywords: Ganzfeld, meta-analysis, parapsychology, power analysis.

Description of the Domain

In the early 1970s a number of investigators were led independently to explore the effects of a perceptual isolation technique (ganzfeld stimulation) on performance in anomalous communication tasks (Braud, Wood, & Braud, 1975; Honorton & Harper, 1974; Parker, 1975). The impetus for this research involved converging evidence that anomalous communication effects were frequently associated with internal attention states characterised by reduced perceptual processing (see Honorton, 1977). A homogeneous visual field (ganzfeld) is produced through diffusion of a bright light source over translucent hemispheres covering the receiver's eyes. Homogeneous auditory stimulation is produced by white noise through headphones. The receiver usually undergoes relaxation exercises at the beginning of the session, then free-associates to describe a randomly selected and remotely located target. The target usually is viewed by a sender who attempts to communicate salient features of its content or meaning to the receiver; in studies without a sender, the target is enclosed in an opaque container. Assessment typically involves blind-ranking or rating similarities between the receiver's ganzfeld-produced imagery and a pool including the target and several decoys.

The Standard Analysis Method

In the prototypical ganzfeld imaging study, receivers attempt to identify the target by ranking perceived similarities between their ganzfeld generated imagery and a judging pool consisting of the target and several decoys. This judging task is "double-blind," such that neither receiver nor experimenter knows the identity of the correct target. Success is defined in terms of the binomial probability associated with the proportion of "direct hits," i.e., correctly-assigned ranks of 1, compared to the null chance expectation of 1/N, where N is the number of candidates in the judging pool (usually four); in the modal case—accounting for approximately three-quarters of the studies—the null hypothesis (of no communication) predicts that the proportion of "direct hits" will not differ reliably from .25.

Variations in Method

Several variations in analysis method also have been reported. A few early studies defined performance in terms of 'binary' or partial hits, a crude weighting scheme that gives credit when the target rank is in the lower half of the rank distribution, such that the chance probability of a hit is .5. Others have used a sum-of-ranks technique that utilises all of the rank data (Solfvin, Kelly, & Burdick, 1978), or standardized ratings of the target and decoys (Stanford & Sargent, 1983). A more radical variation used in a small cluster of studies employed a special set of 2^{10} targets characterised by the presence or absence of 10 binary features (Honorton, 1975); the receivers' ganzfeld impressions were also feature-coded and matched against the 10-bit target code, producing 10 independent binary trials/session. None of these methods account for more than 10% of the studies.

Method

Study Retrieval

The meta-analysis includes all (real-time) ganzfeld imaging studies published in the English-language parapsychology literature between 1974 and 1991. Besides published reports, the meta-analysis also includes doctoral theses and abstracts of otherwise unpublished studies.

Meta-Analysis of Ganzfeld Effect Sizes

To maintain compatibility with previous estimates, the direct hits measure was used whenever possible. The effect size index Cohen's h (Cohen, 1977) was employed. The h index is the (arcsine transformed) difference between the observed proportion of hits and the proportion expected by chance. For studies not amenable to direct hits analysis, approximations to Cohen's h were obtained by dividing the z score by $\sqrt{N}$, where z is the standard normal deviate associated with the reported significance level and N is the total number of trials. In a few cases involving multiple analyses of the same data set, z, N, and effect size were estimated by averaging across the reported measures. Studies reporting only 'nonsignificance' were assumed to have effect size = 0.00.

Table 1. Overall Results

	N studies	*N* investi-gators	Median sample size	Mean effect size	95% confidence interval From	To	*z*	*p*	Fail-Safe Ratio
All studies	73	21	32	0.16	.06	.26	5.74	4.75×10^{-9}	11 to 1
Direct hits studies	53	16	30	0.23	.13	.33	6.75	7.43×10^{-12}	16 to 1

Results

Overall Effect

A total of 73 studies were retrieved. These studies were conducted by 21 independent research teams and involve 4,155 trials contributed by 1,762 subjects. Table 1 summarizes the overall ganzfeld study outcomes. The combined *z*-score is 5.74 ($p = 4.75 \times 10^{-9}$). Rosenthal's (1991) 'Fail-Safe N' estimate indicates that approximately 11 unreported studies averaging null outcomes would be required to reduce the overall significance of the retrieved studies to p=.05. The mean effect size is .16 (95% CI = .06/.26). The mean effect size is equivalent to a success-rate of 32.2% in the standard 4-choice situation. The last row of Table 1 gives the same breakdown for the largest subset of studies involving analysis by direct hits. These studies were contributed by 16 independent research teams and the combined $z = 6.75$ ($p = 7.43 \times 10^{-12}$). The 'Fail-Safe' estimate indicates that approximately 16 unretrieved studies averaging null outcomes would be required to jeopardise the significance of this subset. The mean

Table 2. Statistical Power Analysis for Overall Results

	All Studies	**Direct Hits Studies**
Power Estimate (using average ES & sample size)	0.23	0.35
Expected *N* Studies Significant at $p = .05$, given power estimate	17	19
Observed *N* Studies significant	19	15
Z(Observed vs. Expected)	0.49	-1.17
p(*Z*)	.31	.88

effect size of .23 is equivalent to an average success rate of 35.5% in the typical 4-choice situation and the 95% CI = .13/.33 (approx. 31%/40%).

Statistical Power Analysis for Overall Effect. Table 2 summarizes a statistical power analysis based on the mean effect sizes and median sample sizes for the data in Table 1 (Cohen, 1977, pp. 460-461). For all studies, the power analysis indicates that an average effect size of .16 (at the $p \leq .05$ level) would be detected only about 21% of the time, given the median sample size of 57 trials. The power estimate for direct hits studies (mean ES = .23, mean N = 31 trials) is 23%. As indicated by the last two rows of Table 2, the actual number of significant ($p \leq .05$) studies is consistent with the number expected from the power analysis. It is clear from the meta-analysis that the various alternatives to direct hits assessment have not been effective.

A sample size of 420 trials would be necessary to detect (at $p \leq .05$) an effect size of .16 (all studies) with 95% power. For an effect size of .23 (direct hits), 95% power can be achieved with a sample size of 200 trials.

Impact of Sender vs. No Sender

Figure 1 presents a stem-and-leaf display of the distribution of effect sizes for studies

Figure 1. Stem and Leaf Plot of Effect Size Distribution

No Sender		Sender	
N Studies:	12	N Studies	61
Minimum:	-.582	Minimum:	-.930
Lower Quartile:	-.086	Lower Quartile:	-.020
Median:	.105	Median:	.140
Upper Quartile:	.305	Upper Quartile:	.320
Maximum:	.730	Maximum:	1.440

	-9	3
8	**-5**	
	-4	3 0
0	**-3**	7 4 2 0
	-2	7 0
	-1	6 2 0
0 0 0	**-0**	5 4 2 2 1
0	**0**	0 0 4 7 7 7 7 9
	1	1 1 1 1 3 4 5 5 7 8 8 8
9 7 1	**2**	2 3 4 4 4 7
2	**3**	1 2 4 4 7 8 8
0	**4**	2 2 2 4
	5	8
3	**7**	2
	8	1 7
	9	5
	13	3
	14	4

Note: Outlying values are underscored.

Table 3. Studies with and without Senders

	N studies	*N* investi-gators	Median sample size	Mean effect size	95% confidence interval From	To	*z*	*p*	Fail-Safe Ratio
Sender	61	20	30	0.17	.07	.27	5.70	$6x10^{-9}$	11 to 1
No Sender	12	7	33.5	0.10	-.10	.30	1.31	.095	--
Difference							1.49	.137	

with and without senders (Tukey, 1977). A statistical summary is provided in Table 3. Senders were employed in 61 studies (3,684 trials) by 20 independent investigators. The combined *z*-score is 5.70 ($p=7x10^{-9}$). Rosenthal's 'Fail-Safe N' estimate indicates that approximately 11 unreported studies averaging null outcomes would be required to reduce the overall significance of the retrieved studies to $p=.05$. The mean effect size of .17 is equivalent to a success rate of 32.5% in the typical 4-choice situation and the 95% CI = .07/.27, i.e., 28%/37%.

The remaining 12 studies (470 trials) did not employ senders. These studies, contributed by seven independent investigators, have a combined z = 1.31 ($p=.095$). The mean effect size is .10 (95% CI = -.10/.30). Thus, the studies without senders show no overall evidence for anomalous communication.

Transforming the mean effect sizes for studies with and without senders back to proportion of hits, the difference between the two conditions was tested using the *z* test for differences between binomial proportions. The resulting *z* of 1.49 is nonsignificant (p = .1371, two-tailed). The effect size for the difference is .023. While this difference is not significant, only the studies with senders show a significant overall ganzfeld communication effect.

Since the sender/no sender comparison is between rather than within studies, i.e., not based on systematic within study comparison of sender impact, the observed difference could be due to factors other than the presence or absence of senders. Investigators tend to implement experimental procedures in various ways, sample from different populations (e.g., students, volunteers), employ various instructional sets, and use a variety of different target stimuli. Such variations could conceivably account for the observed differences.

To assess this possibility, an analysis was performed on the subset of five investigators who contributed both studies with senders and without senders. This subset comprises only about 20% of the investigator base, but 40% of the total number of trials (N = 1,666). These investigators reported 25 studies with senders (N = 1,497, mean ES = .301, SD = .420, combined $z = 5.84$, $p = 3.15 \times 10^{-9}$). This is equivalent to a hit rate of 38.96% in the typical 4-choice judging situation. Seven studies without senders yield a mean ES = .017 (N = 169, SD = .351, combined $z = 0.31$, $p = 378$), or 25.74% hits in the 4-choice situation. For this subset the difference in the proportion of hits with and without senders is significant ($z = 3.39$, $p = .0007$, two-tailed, 95% CI from .06/.20). The effect size of the difference is .083. This analysis indicates that sender/no sender differences in performance are not likely to be the result of differences in laboratory or investigator style factors. Statistical power analysis indicates that approximately 1600 trials would be needed to achieve a 95% likelihood of detecting a difference of this magnitude.

Conclusions

This report has focused on two aspects of a larger meta-analytic study of anomalous communication in the ganzfeld: estimates of the main effect (overall magnitude), and the impact of one moderator variable (presence or absence of a target observer or sender). Regarding the main effect, the meta-analysis suggests the following conclusions:

- The combined evidence across 73 studies and 21 independent investigators provides strong evidence for anomalous communication in the ganzfeld: the null hypothesis is highly implausible given the overall probability of 4.75×10^{-9}.
- The fail-safe estimates render alternative explanations based on selective reporting of positive results untenable. The overall observed outcome would remain statistically significant even if there were 25,696 unretrieved ganzfeld trials, averaging null outcomes (Fail-safe estimate x N studies x mean trials per study).
- Statistical power analysis indicates that the observed number of statistically significant ($p \leq .05$) studies is consistent with the overall effect size estimates for all studies and direct hits studies.
- The meta-analysis fails to support the advantage of nondirect hits analysis methods.
- The power analysis indicates that anomalous communication effects should be detectable at conventional significance levels in 95% of ganzfeld studies employing direct hits analysis and sample sizes ≥ 200 trials.

Due to the small number of studies without senders, the meta-analysis is less clear concerning the moderating effect of the sender. The strongest evidence regarding sender impact is based on an analysis of the subset of five investigators who each contributed studies with and without senders, thus holding laboratory, sampling, and investigator style factors constant. This analysis indicates that the presence of a sender results in significantly superior anomalous communication effects, though the magnitude of the difference is small. Moreover, since, with one exception (Raburn, 1975), the primary studies were not designed to systematically assess sender versus no sender conditions, the meta-analysis cannot address the underlying source of this difference. New studies, specifically designed to compare sender/no sender effects, will be needed to assess the extent to which the sender's influence is instrumental (intrinsic to the communication process) or peripheral (based on psychological or motivational factors).

+/or determines data type..

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APPENDIX D

Effects of the Sender on Anomalous Communication in the Ganzfeld

Effects of the Sender on Anomalous Communication in the Ganzfeld

Research Protocol

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Approved For Release 2000/08/10 : CIA-RDP96-00787R000300230001-5

Project Overview

The objective of this project was to develop a detailed protocol for experimental assessment of the effects of a sender on anomalous communication in a ganzfeld setting. This objective has been realized through the completion of three tasks:

- A meta-analysis of existing ganzfeld communication research was performed and used in a statistical power analysis to estimate the sample sizes needed to reliably detect (a) an overall anomalous communication effect and (b) a difference between sender and no sender conditions (Honorton, 1992). Given the effect size associated with the overall ganzfeld effect, the power analysis indicated that 95% reliability should be achievable in studies employing at least 200 trials. The small number of studies without senders, while limiting the usefulness of meta-analysis of sender impact from the existing data, nevertheless indicates that overall evidence for anomalous communication in the ganzfeld is present only in the subset of studies using senders.

- Meta-analysis of moderator variables in this domain indicates a reliable correlation between performance in anomalous communication tasks and the psychological trait of extraversion. Less certain but reasonably consistent evidence was also found supporting the predictive utility of abundance of self-reported anomalous experiences, history of prior testing, involvement with mental disciplines such as meditation, and certain other personality dimensions (Honorton, in press).

- Informed by the above meta-analytic studies, development of an automated, computer-based testing system and protocol for new studies sender effects in anomalous communication. The testing system and protocol are described in this document.

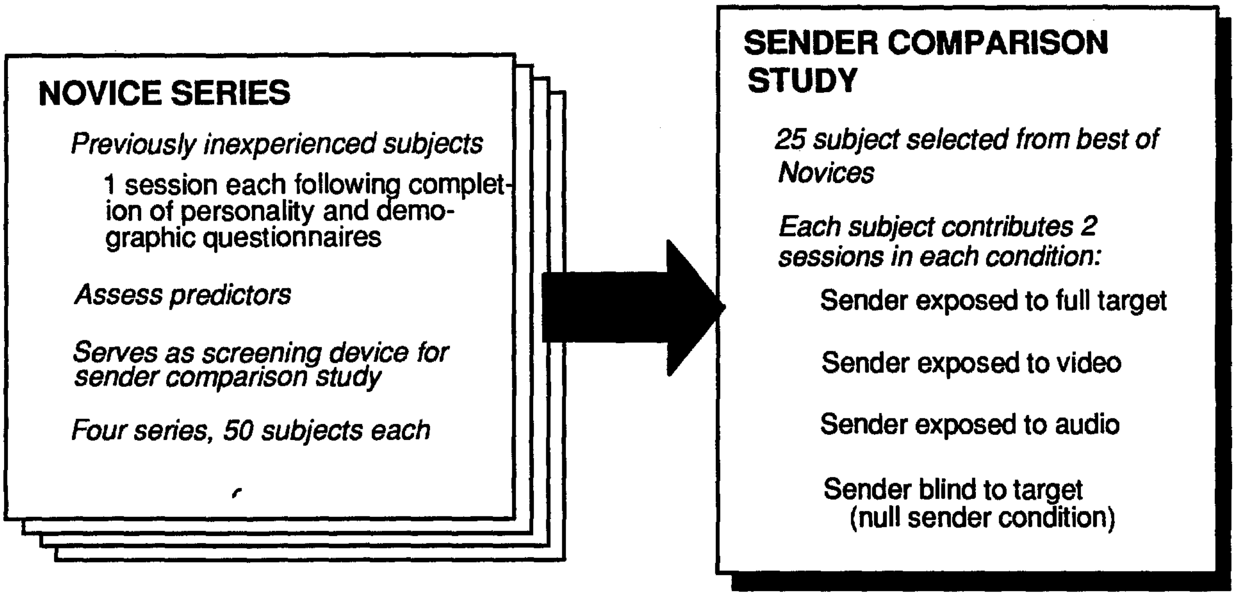
Study Design

The basic research methodology and design comply with the PRL design described by Honorton, Berger, et al. (1990). A new video ganzfeld control system has been developed with modifications to enable double-blind sender comparisons. (See **Video Ganzfeld System**.) New target pools have been created and coded to enable quantitative characterization of targets. (See **Target Stimuli**.)

The project involves two interrelated types of studies. *Novice* studies provide initial training in ganzfeld communication tasks for previously inexperienced subjects. The novice studies form the primary basis for selecting subjects for the sender comparison study. The novice studies are conducted in four *series*. In each series 50 novice subjects or *receivers* complete one ganzfeld session involving full target presentation to a sender. A secondary function of the novice series is to test refinements in predictor measures. (See **Predictors**.)

Successful novices will be asked to participate in the sender comparison study. Rather than simply comparing performance with and without a sender, we have opted for a more informative comparison of sending modes in which a sender is always physically present. Instead of varying the presence or absence of the sender, we will vary the degree of target information available to the sender. Since we are using dynamic video stimuli, each target has both visual and auditory components, enabling comparison of four conditions: Video+audio ("Full target") components presented to sender, Video only, Audio only, neither component ("Null sender" condition). The specific condition for a given session is randomly selected and unknown to either experimenter or subject until the end of the session. (See Figure 1.)

Figure 1. Study Design



Video Ganzfeld System

The video ganzfeld system is a second-generation hardware/software control system for the study of anomalous communication in the ganzfeld. It is essentially an updated version of the PRL automated ganzfeld system (Honorton, et al., 1990), providing automated computer control of major aspects of the ganzfeld session, including:

- Random selection of the target in novice series
- Random selection of sender condition in sender comparison series
- Automated VCR control and presentation of the target (or target element) to the sender during sending periods
- Presentation of judging pool (target and decoys) to receiver (subject) and experimenter during the post-session blind-judging procedure
- Presentation of judging rating scales and registration of blind-judging responses
- Data recording and storage
- Automated presentation of subject feedback following blind-judging and data recording

The system also includes modules controlling series design and subject registration which are described below.

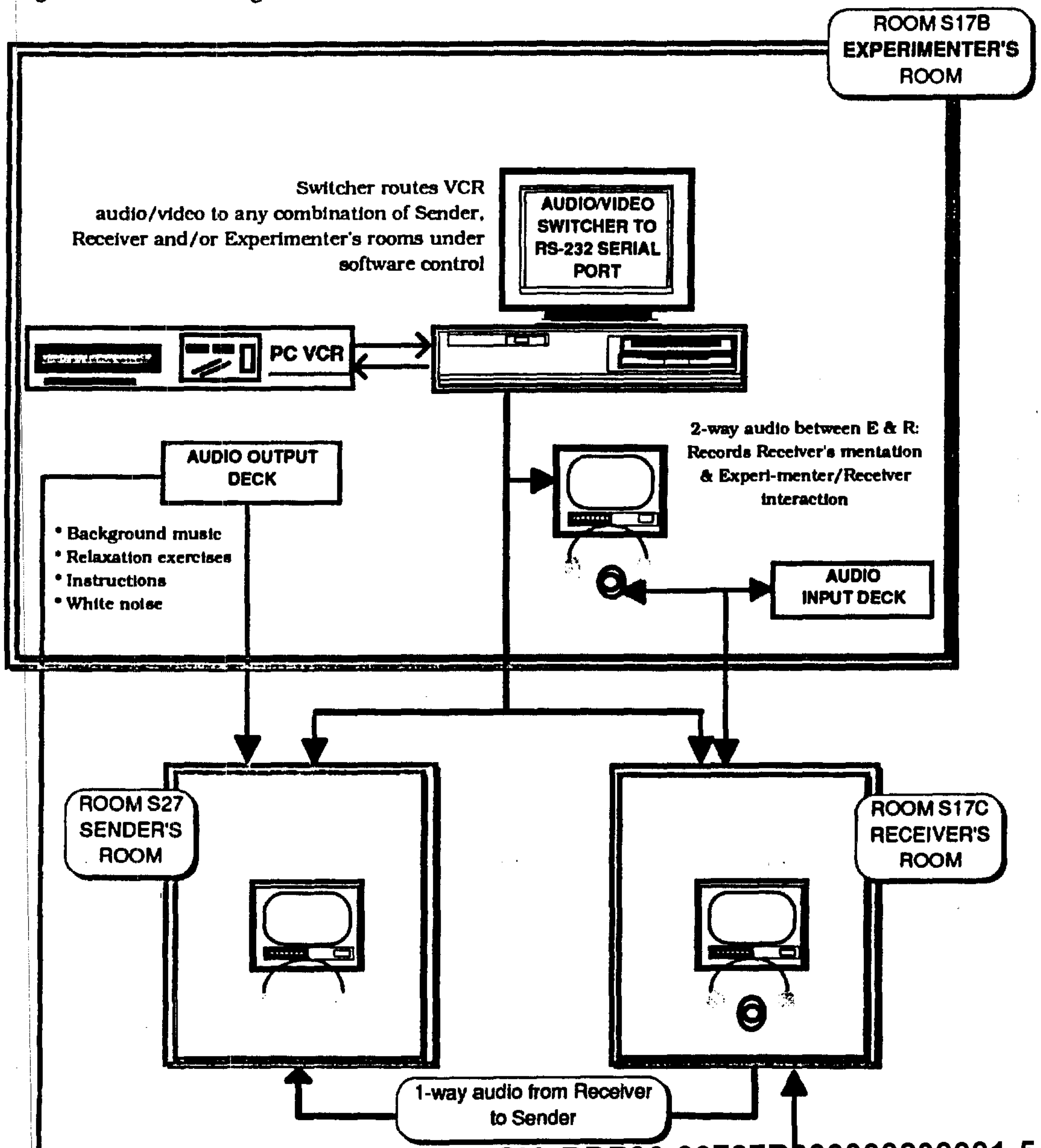
Hardware System

The video ganzfeld system runs under Microsoft Windows 3.1/DOS 5 on a 33MHz 80386DX computer. The computer is equipped with 210 MB fixed disk, 8 MB DRAM, four RS 232 serial ports, an 80387 numeric coprocessor, and a super VGA monitor. The video subsystem has onboard genlock capability to enable transfer of the VGA graphics screen to an NTSC composite monitor in the receiver's room.

The target presentation subsystem is an NEC PC/VCR, a frame-accurate NTSC videocassette recorder with an onboard RS 232 serial interface. All VCR functions are controlled via computer software. Custom-designed video switchng circuitry enables the computer to route VCR video and audio signals (as well as the computer graphics screen) to any combination of the three experimental rooms (experimenter's monitoring room, receiver's room, sender's room). Each room is equipped with a 14 in. Panasonic color monitor and headphones.

Two audio cassette decks are used. One deck enables two-way audio communication between experimenter and receiver, and records the receiver's mentation report during the session as well as any interaction between experimenter and receiver. The other audio cassette deck plays prerecorded relaxation exercises, session instructions, and white noise during the session. One-way audio communication from receiver to sender enables the sender to monitor the receiver's mentation report during the session. Figure 2 provides a schematic diagram of the communication flow during the experimental session.

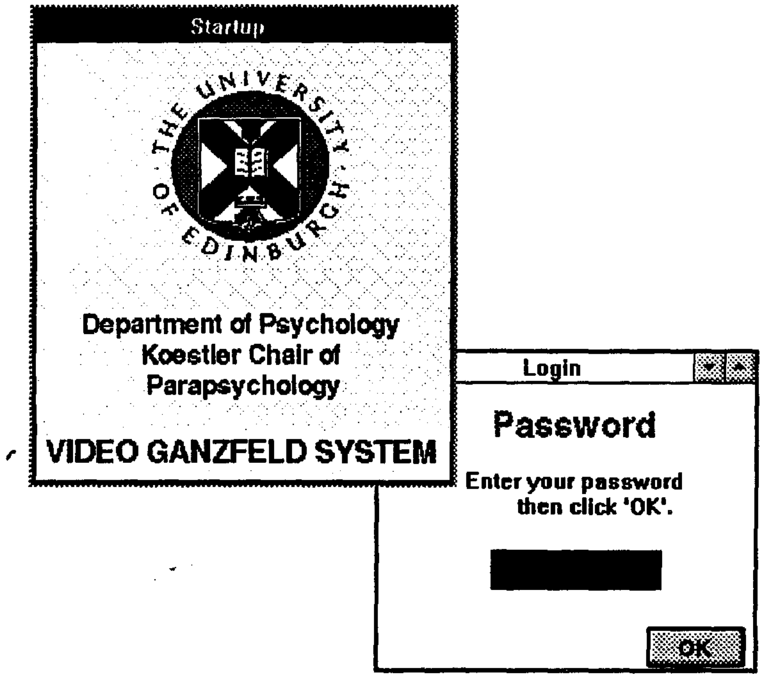
Figure 1. Schematic Diagram of Video Ganzfeld Communication Flow



Software System

The video ganzfeld software runs under Microsoft Windows 3.1. The initial startup sequence requires the experimenter to enter a valid security password. (See Figure 3.) The system automatically terminates if a valid password has not been entered.

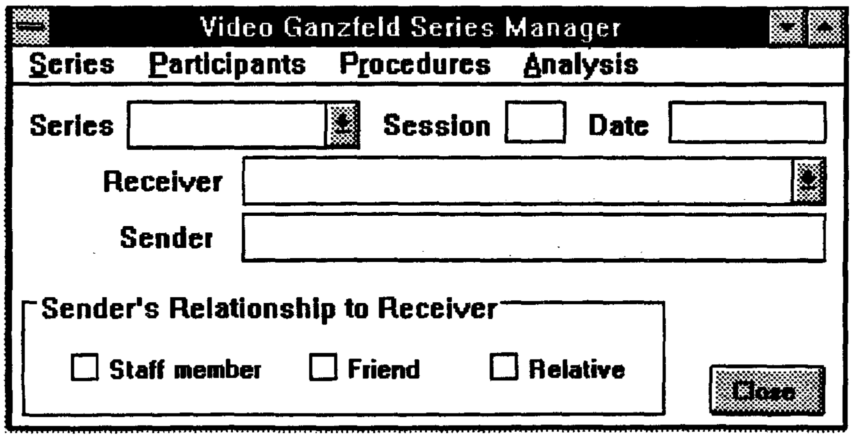
Figure 3. System Startup Sequence



Series Manager

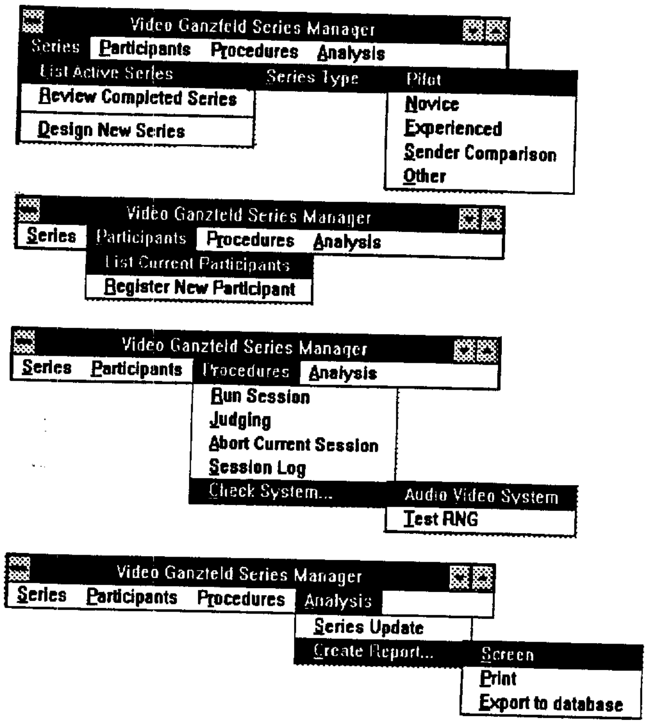
Upon entry of a valid password, the Series Manager is loaded. Series Manager is the central control program. It enables the experimenter to design new experimental series, register new subjects, run experimental sessions, and export data files to database management packages. (See Figure 4.)

Figure 4. Video Ganzfeld Series Manager



The Series Manager menu structure is shown in Figure 5. Each of the major menu components is described below.

Figure 5. Series Manager Menu Structure



Series

The Series menu allows the experimenter to list currently active experimental series, review completed series, and design a new series. The Series Design option is the most important function in this menu. It provides the only means through which a new experimental series can be created and requires advance specification of the study sample size (number of trials and subjects), the series type, and the target display (sender) mode:

- **Full Target:** The sender will be exposed to both the video and auditory components of the target episode
- **Sender Comparison:** The system randomly determines whether the sender is to be exposed to the full target, its video component, its auditory component, or a blank screen (null sender mode)

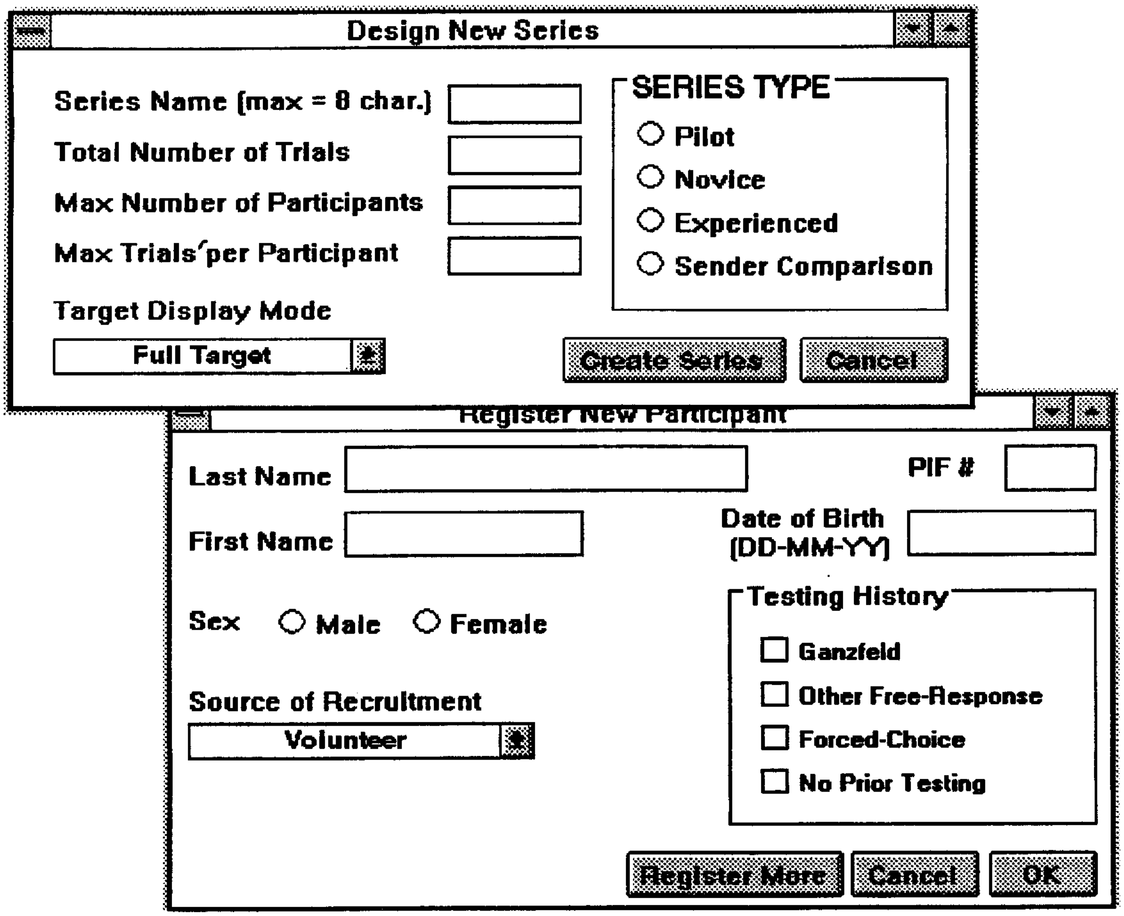
Data input validation routines check for inappropriate or contradictory input (e.g., that the product of the maximum number of participants and maximum number of trials per participant does not exceed the total number of trials). The Series Design parameters are stored in a series startup file. The file is read into memory when the series is selected from the Series Manager and the system checks to insure that the specified sample size and maximum trials per subject are not exceeded in the series.

Participants

The Series Manager Participants menu allows the experimenter to list current participants in the selected series and to register new participants. In experiments in which each subject contributes multiple sessions, the list of current participants includes the total number of sessions completed by each subject.

The Participant Registration option provides the only valid means by which new participants can enter an experimental series. Upon selecting this option, the experimenter is presented with a dialog box which prompts him to enter the subject's name, a unique identification (PIF) number, the participant's sex, date of birth, source of recruitment into the study (from a standardized list), and prior testing history. As with the Series Design dialog, data input validation routines are used to insure appropriate input and check for contradictions (e.g., checking "No prior testing" and one of the other prior testing options). The Series Design and Participant Registration dialogs are shown in Figure 6.

Figure 6. Dialogs for Series Design and Participant Registration

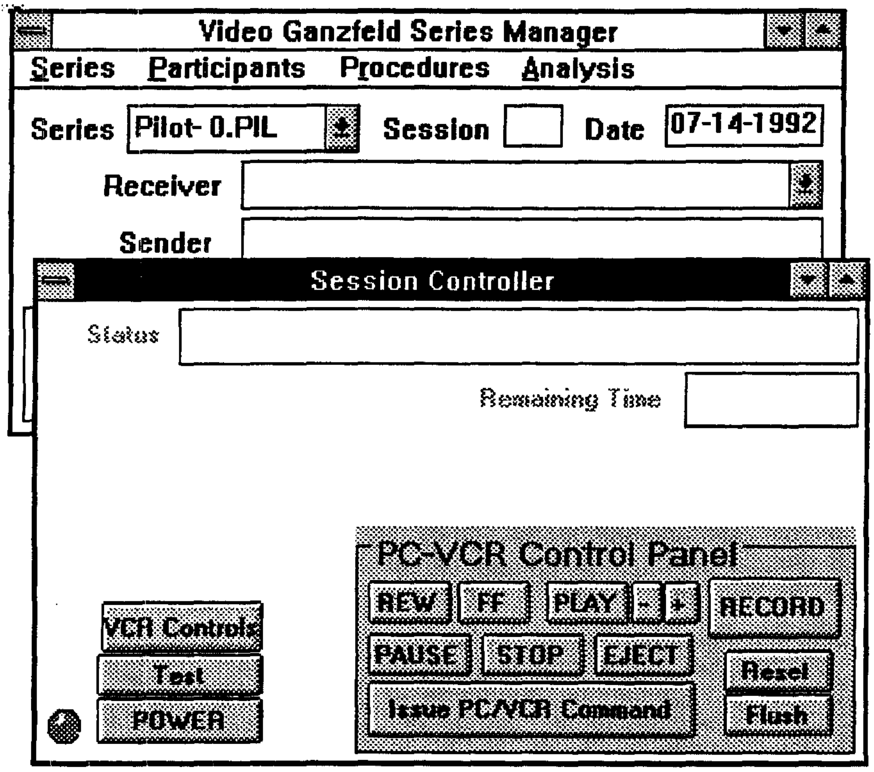


Procedures

The primary options available on the Procedures menu enable the experimenter to run a session and to initiate the blind-judging procedure at the end of the session.

When the experimenter selects "Run Session" from this menu, Series Manager opens a Session Controller window (Figure 7).

Figure 7. Video Ganzfeld Session Controller

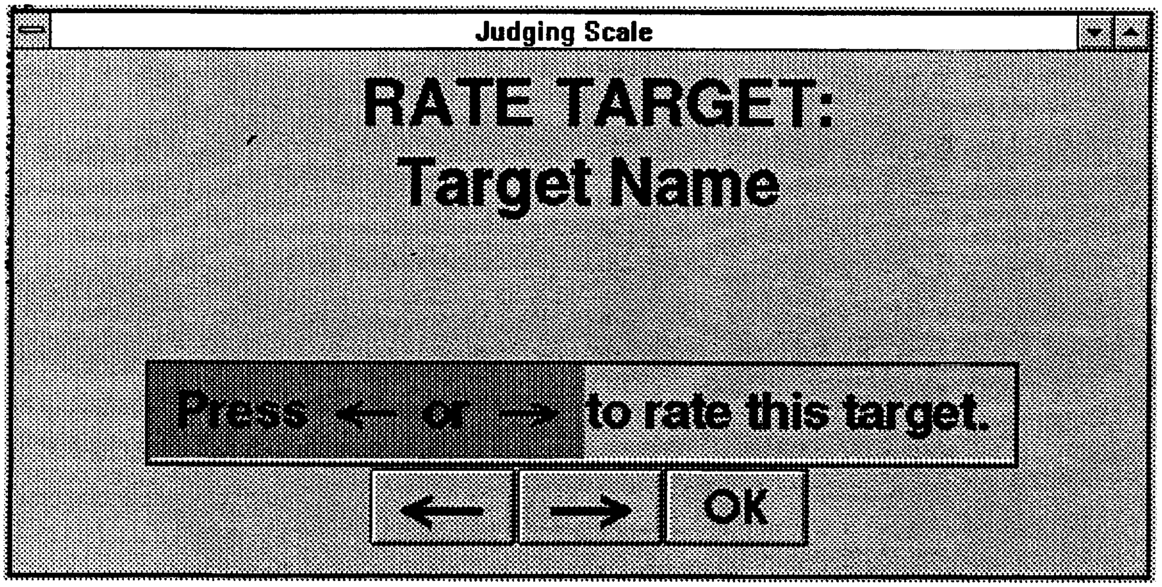


The experimenter turns on the PC-VCR by clicking the "POWER" button. The session is begun when the experimenter clicks "RUN." After randomly selecting a target for the session, the Session controller reads a file containing the digital addresses of each target in the pool. The program verifies that the proper videocassette target pool has been inserted into the PC-VCR, then searches for the target on the videocassette and places the PC-VCR into pause mode. The system clock is used to time the onset of each of the six sending periods in the session. Fifteen seconds prior to each sending period, the program uses the PC-VCR character generator to display a message on the sender's monitor, announcing that a sending period is about to begin, then displays the target on the sender's monitor. In sender comparison studies, the system performs another randomization to determine whether the sender will be shown the complete target, the target video component, audio component, or a blank screen, then routes the appropriate target element to the sender's monitor. At the end of the sending period, the program rewinds the videocassette to the beginning of the target and the PC-VCR is placed in pause mode. This procedure is repeated for each of the six sending periods

The Session Controller provides the experimenter with a count down of the number of minutes remaining in the session.

At the end of the session, experimenter and receiver, communicating via intercom link, review the receiver's mentation. The experimenter then selects "Judging" from the Series Manager Procedures menu and the program displays each of the four possible targets on both experimenter's and receiver's TV monitors. The four elements in the judging pool are presented in one of four random sequences. The receiver is prompted to identify whatever correspondences they perceive between their ganzfeld mentation and each of the four potential targets. The receiver is given the option to view any or all of the elements in the judging pool as many times as desired, then procedes to perform the blind judging task. The program displays a judging scale (Figure 8) on the receiver's monitor for each of the four possible targets in the judging pool. The judging scale shows a brief descriptive name for each target, a thermometer-style rating scale, and three buttons. Using a mini-joystick, the receiver rates the degree of perceived similarity between each potential target and their mentation. The scale ranges from 0% to 100% and the current value of the scale is displayed both numerically and graphically as the receiver clicks either the left or right arrow buttons.

Figure 8. Video Ganzfeld Judging Scale



When the receiver is satisfied with the rating assigned, she or he presses the "OK" button. The judging procedure is repeated for each of the four potential targets in the judging pool. The program checks for tied ratings and prompts the receiver to re-rate in the event of a tie. Once the receiver has rated all of the elements in the judging pool, the program converts the ratings to ranks and stores the ratings and ranks as fields in the session database record. The program calculates a standardized rating (*z*-score) based on the difference between the rating assigned to the correct target and the mean of the three decoy ratings divided by the standard deviation of of all four ratings (Stanford & Sargent, 1983).

The program times the duration of the judging procedure from initial presentation of the four judging pool elements to completion and adds it to the session database record.

The Series Manager Procedures menu includes three additional options: "Abort current session," "Session log," and "Check System." The abort session option is used to terminate an ongoing session prior to completion. Premature termination of a session may only occur in the event of a protocol violation (e.g., sender or receiver leaving their respective rooms after the beginning of the session), equipment failure, or an emergency situation. When "Abort session" is selected, the system displays a dialog box prompting the experimenter to enter his or her security password and indicate the specific reason for terminating the session. This information, along with the the participant's ID, and the date and time are written to a series abort file. Abort session is not available after the blind judging procedure has been completed.

Session log enables the experimenter to register comments concerning the current session and "Check System" performs diagnostics on the audiovisual and randomization functions of the system.

Target Stimuli

Target Pool

Following Honorton, et al., (1990), target stimuli consist of brief (35-80 sec.) video excerpts from a variety of films and documentaries. Two target pools, each containing 40 targets (10 judging pools of four targets each), have been prepared. Each target pool is stored on one 90-min. .5 in. VHS videocassette tape. Digital addresses on each videocassette enable frame-accurate access of targets via the video ganzfeld/PC-VCR computer link. A unique digital header is recorded on each videocassette and is read by the computer at the onset of each experimental session. Accidental insertion of a videocassette other than that containing the designated target pool is automatically detected and results in termination of the session.

Based on an analysis of target success-rates in the PRL experiments, approximately half of the targets were taken from among the most successful PRL dynamic targets. The remainder of the targets are new. Pool A will be exclusively used for the Novice Screening Series and Pool B will be used for the Sender Comparison Series. Since the latter series will include sessions in which the sender will be exposed only to the audio soundtrack portion of the target, the elements in Pool B include a high proportion of targets with descriptive narration.

Measurement of Target Attributes

The quantification of complex target material has long eluded investigators of anomalous communication. The quantitative characterization of target attributes is important for a number of reasons, for example:

- Development of more statistically powerful methods for assessing target/description correspondences,
- Detection and elimination of targets associated with strong response bias (i.e., targets that tend to be selected or rejected because of their intrinsic characteristics),
- Detection and elimination of targets that activate perceptual defense,
- Identification of targets that are excessively difficult to describe,

- Identification of elements of target environments that may be especially amenable to retrieval via anomalous communication.

Recently, major advances have been made with regard to certain aspects of this problem as it specifically applies to remote viewing studies (May, et al., 1985; 1990). While aspects of May's conceptual schema can also be applied to ganzfeld research, there are two aspects of the latter that call for a somewhat different approach: (1) The standard ganzfeld mentation protocol focuses upon the elicitation of unconstrained spontaneous imagery rather than an explicit focus upon describing the target. (2) The video targets are themselves quite different from those typically used in remote viewing research: They include auditory components (e.g., music, dialogue, narration, sound effects), occasionally major transitions in perspective, highly evocative dramatic and comedic scenes, etc.

For these reasons, we have adopted a somewhat different approach, consisting of two distinct aspects: (1) Specific descriptors tailored to the content of the target pools, and (2) generic characteristics derived from environmental psychology.

Content-based Descriptors

Each target has been coded with respect to Theme, Tone, and Content. Each item is coded

Table 1. Content-based Descriptors

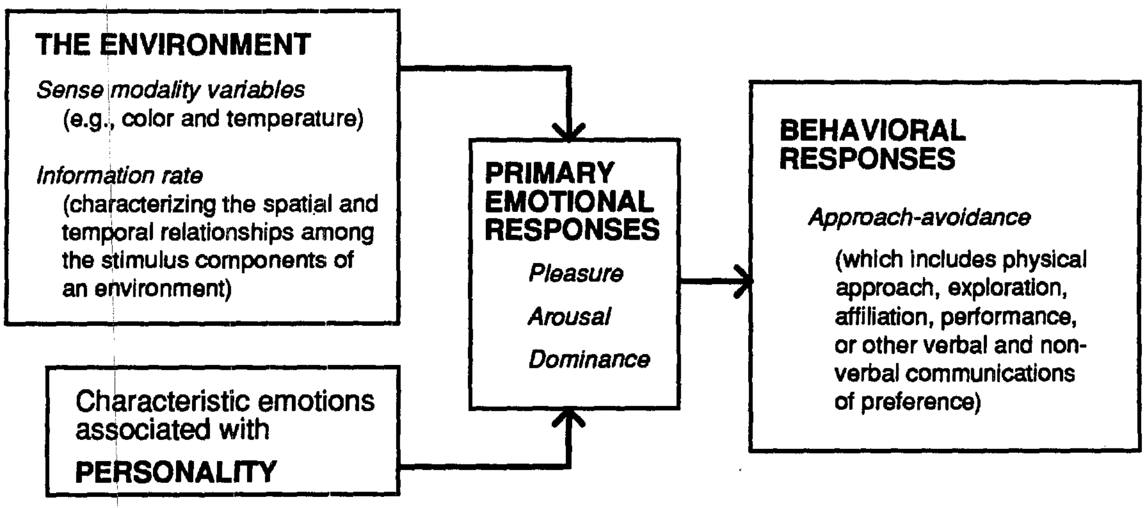
THEMES	Nature/wildlife Fantasy/religion/mythology Aggression/battles/warfare/conflict Social interactions Sports/athletics/acrobatics Art/dance/music Places/travel/exploration Cartoons/animation
TONE	Humor Documentary Action Drama Wonderment/awe Light entertainment
CONTENT	People Animals Fantasy/mythical characters Water Rocks/hills/mountains Trees/flowers/foliage Land vehicles/scenes Terrestrial flight scenes Underwater vehicles/scenes Architecture/urban scenes Technology/objects/devices/tools Space/planets/galaxies Music

on a four-point scale, where 0 = absent, 1= present, 2= prominent, and 3=dominant. (See Table 2). The content-based descriptors are used (a) in construction of orthoginal judging pools and (b) in exploratory analysis of target attribute correlates of anomalous communication.

Generic Characterization of Targets based on Environmental Psychology Approaches

The above approach represents what Mehrabian and Russell (1974) describe as "the most common, but least parsimonious, approach... the use of the everyday language of specific events and entities" (p. 6). They point out that this approach does not permit comparison across environments, "... and it is impossible to analyze behavioral changes as functions of changes in environments so described" (p. 6). Mehrabian and Russell survey a wide array of evidence pointing to the advantage of generic characterization of environments in terms of the primary emotional responses they elicit and a (psychologically-based) measure of information rate. Their general framework is illustrated below in Figure 9.

Figure 9. Mehrabian & Russell Framework for Characterizing Environments



After Figure 1.1 of Mehrabian & Russell (1974).

Within this framework, environments are coded using semantic differential scales measuring the three primary emotional responses (pleasure or evaluation, arousal or activity, dominance or potency) and information rate. The scales are reproduced in the appendix. Each of the targets has been coded on these four scales. We believe that this approach may provide a basis for broader comparison across laboratories and target sets than more traditional methods. It of course remains to be seen how useful it will be as a predictor of success in anomalous communication.

Predictor Measures

Extraversion and Openness to Experience

Performance in anomalous communication tasks has been found to correlate with the psychological trait of extraversion in a recent meta-analysis of 15 studies by five independent investigators (Honorton, Ferrari, & Bem, 1990). The mean correlation is small ($r = .20$) but consistent across investigators, studies, and personality measures.

While the meta-analysis provides strong evidence that a relationship exists between anomalous communication and extraversion, it is silent as to the nature of the relationship. Extraversion is commonly associated with sociability (gregariousness), but it is now known that there are at least five other components of extraversion. For this reason, we have chosen the NEO Personality Inventory (Costa & McRae, 1985), an instrument that measues six facets of extraversion. Recent research implicates sensation seeking as an instrumental factor in the ganzfeld experience (Glicksohn, 1991) and we are especially interested in the possibility that it also correlates with performance in anomalous communication tasks. We also will use the NEO PI Openness scale, and its six facets, because a number of studies have indicated a relationship between anomalous communication and various measures of openness to experience. Table 2 lists the six facets of extraversion and openness.

Table 2. Facets of Extraversion and Openness

Scale	Facet
EXTRAVERSION	1. Warmth 2. Gregariousness 3. Assertiveness 4. Activity 5. Excitement Seeking 6. Positive Emotions
OPENNESS	1. Fantasy 2. Aesthetics 3. Feelings 4. Actions 5. Ideas 6. Values

A computer program scores the questionnaire and presents graphic profiles for each of the six facets of extraversion and openness. Statistical power analysis (Cohen, 1977) indicates that a sample size of 200 subjects will achieve a 90% likelihood of detecting a correlation of .2 at $p<.05$. With $N \geq 200$, the critical value of r ($p \leq .05$) is within the 95% CI of the meta-analysis.

Other Moderators

Meta-analysis of three novice experiments in two independent laboratories indicates that initial anomalous communication performance in the ganzfeld is related to four other factors (Honorton, in press):

- The number of types of personal "psychic" experiences subjects believe they have had,
- Experience with mental disciplines such as meditation,
- Classification as Feeling/Perception on the Myers-Briggs Type Indicator, and
- Prior formal testing involving anomalous communication tasks.

Across the three studies, only 15 subjects (about 5%) satisfied all four predictors, but 11 of them successfully identified their targets (effect size = 1.03). When the least frequently satisfied condition (prior testing) was eliminated, 99 subjects in the three studies satisfied the remaining three predictors, with an effect size of .39. Subjects who did not satisfy the three-predictor model (N = 190) produced a nonsignificant effect size of .07.

Myers-Briggs Feeling/Perception is highly correlated with the NEO Openness Scale used in this study. We have developed more refined items regarding reported personal anomalous experiences, prior laboratory testing, and mental disciplines. Prior to contributing to the novice series (total N = 200), subjects will complete the NEO-PI Extraversion and Openness scales and a demographic survey incorporating measures of personal experiences and prior testing. If the predictive utility of these factors is confirmed in the new novice series, a composite predictor measure will be used in addition to novice target acquisition to select subjects for the sender comparison study.

Subjects

Previous research also indicates that artists and musicians are particularly successful in anomalous communication tasks (Schlitz & Honorton, 1992). For this reason, we will recruit as many subjects as possible from University music and arts departments and local creative and performing arts groups.

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Appendix

Semantic Differenetial Scales Used for Generic Target Characterization (Mehrabian & Russell, 1974)

I. Primary Emotional Responses

Instructions: Take a few moments to really get into the mood of the situation depicted in the target episode; then rate your feelings in the situation with the adjective pairs below. Some of the pairs might seem unusual, but you'll probably feel more one way than the other. So, for each pair, put a check moark close to the adjective which you believe to describe your feelings better. The more appropriate the adjective seems, the closer you put your check mark to it.

TARGET NAME	TAPE	TAPE ADDR. (START : END)
		:

RATER

EVALUATION

Happy										Unhappy
Pleased										Annoyed
Satisfied										Unsatisfied
Contented										Melancholic
Hopeful										Despairing
Relaxed										Bored

ACTIVITY

Stimulated										Relaxed
Excited										Calm
Frenzied										Sluggish
Jittery										Dull
Wide-awake										Sleepy
Aroused										Unaroused

POTENCY

Controlling										Controlled
Influential										Influenced
In control										Cared-for
Important										Awed
Dominant										Submissive
Autonomous										Guided

II. Information Rate

Instructions: Please use the following adjective pairs to describe the situation depicted in the target episode. Each of the following adjective pairs helps define the situation or the relation among the various parts of the situation. Put a check mark in one of the boxes to indicate what you think is an appropriate description.

Varied										**Redundant**
Simple										**Complex**
Novel										**Familiar**
Small-scale										**Large-scale**
Similar										**Contrasting**
Dense										**Sparse**
Intermittent										**Continuous**
Usual										**Surprising**
Heterogeneous										**Homogeneous**
Uncrowded										**Crowded**
Asymmetrical										**Symmetrical**
Immediate										**Distant**
Common										**Rare**
Patterned										**Random**

APPENDIX E

A Preliminary Study of Anomalous Perception During Lucid Dreaming

A Preliminary Study of Anomalous Perception during Lucid Dreaming[1]

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Several studies (reviewed in Child, 1985) have found evidence supportive of the existence of anomalous perception in dreams. The protocols for attempting to elicit anomalous perception in dreams fall into three main categories.

The first type, which has accumulated the larget amount of data, referred to by Child as "general ESP," is known in the popular literature as "dream telepathy." This entails the use of two research subjects, a "sender" and a "receiver." The sender subject concentrates on target information while the receiver subject is in REM sleep, presumably dreaming. The subject's dream content report is later analyzed for correspondence with the target information.

The second category is "precogntion," anomalous perception of future events. In these studies, the sender subject does not select or concentrate on the target until the receiver subject has already attempted to dream about and report on it.

The third type of dream anomalous perception, of most relevance to the present investigation, is called "clairvoyance," referring to the information acquired without a human "sender" intermediate. The protocol requires that the information in the target is not known to the experimenters, so that none could inadvertently act as a "sender."

The use of lucid dreaming to study "clairvoyant" type anomalous perception in dreams may enhance the subjects' ability to acquire accurate information about a remote target. Lucid dreaming is dreaming with awareness that one is dreaming (LaBerge, 1985). In the lucid dream state, one can deliberately alter the course of the dream according to one's intentions. Thus, a subject attempting to "see" a target photograph could decide in a lucid dream to seek out a dream image of the target, rather than relying on the possibility of the target spontaneously appearing in the dream. Lucid dreaming anomalous perception trials might be more similar to waking anomalous perception trials in that in both the subject makes a deliberate attempt to concentrate on and describe a remote stimulus.

This pilot experiment was designed to explore the potential for using the REM lucid dreaming state (dreaming while knowing that one is dreaming) for anomalous perception.

Procedure

Training in Lucid Dreaming

The general strategy of this pilot study called for subjects to induce lucid dreams in which they dream about Remote Viewing (RV) targets (National Geographic scenes sealed in opaque envelopes). Thus, training in lucid dreaming was the first step.

The subjects were selected from 1) subjects in previous RV studies who had demonstrated above normal RV capability (source: SAIC), and 2) subjects who had in prior studies shown above normal ability to induce lucid dreams (LD) (source: LI). The previous RV subjects were

[1]FINAL REPORT: SAIC SUBCONTRACT NO. 29-92-0085-71

compensated according to existing contracts with SAIC. The LD subjects participated as volunteers.

All subjects received two forms of training in lucid dreaming: 1) They were provided with a home-study course in lucid dreaming developed by the Lucidity Institute. 2) They attended two weekend seminars. The first seminar introduced subjects to lucid dreaming skills and the use of the DreamLight lucid dream induction device, which has been shown to effectively enhance the frequency of lucid dreaming in previous studies.

Lucid dreaming RV trials

While practicing lucid dream induction techniques and using DreamLights, subjects attempted to show RV in lucid dreams using the following procedure. At the first seminar each subject received a sealed opaque envelope containing a target photo, which had been selected from sets of five orthogonal National Geographic scenes. Subjects were asked place the target envelope in the bedroom in which they were sleeping, to induce lucid dreams using the DreamLight, and to attempt to locate the target envelope in a lucid dream. In the lucid dream they were to try to open the envelope and examine its contents. Upon awakening they were to describe in detail (with words and pictures) what they had seen. The target description and the target envelope (unopened) were then sent to Dr. Edwin C. May at SAIC for analysis. Upon receipt, Dr. May sent back the target photograph (for feedback) along with another sealed target envelope. The procedure was repeated for as many trials as the subjects could complete during the six month pilot study period.

The coded lucid dream target viewing reports were given to a judge blind to which who rank ordered each set of five orthogonal scenes including the target for degree of correspondence with the lucid dream report. Another judge rated each set of five targets for quality of correspondence of the description given in the report, using an 8 point scale (see Table. 1).

Table 1. Quality Scale

0	No correspondence.
1	Little correspondence.
2	Some correct elements, but not sufficient to suggest results beyond chance expectation.
3	Mixture of correct and incorrect elements, but enough of the former to indicate viewer has made contact with the site.
4	Good correspondence with several matchable elements intermixed with incorrect information.
5	Good correspondence with unambiguous unique matchable elements, but some incorrect information.
6	Good correspondence with good analytical information and relatively little incorrect information.
7	Excellent correspondence, including good analytical detail, with essentially no incorrect information.

Results

Seven subjects successfully completed at least one trial, visiting, viewing and reporting on the appearance of the target in a lucid dream. Four subjects were from the RV group and three were from the LD group. Three subjects were female, four male. Data was collected from 21 trials. Individual subjects contributed 1-7 trials each (mean=3).

Rank order

See Table 2 and Figure 1 for the distributions of rank orders for Targets and Non-targets. Examination of Figure 1 suggests that Non-target ranks were randomly distributed, while Targets showed higher ranks than expected by chance. Sum of ranks statistics were computed for the combined trials (N=21) and also for individual subjects. For individual subject statistics, see Table 3. For the combined trials (N=21), a moderate effect size was obtained: ES=0.368 (z=1.685, p=.046).

Table 2. Distribution of rank orders for targets and non-targets.

Rank	Target N	% Targets	Non-target N	% Non-targets
1	7	33%	14	17%
2	5	24%	16	19%
3	3	14%	18	21%
4	4	19%	17	20%
5	2	10%	19	23%

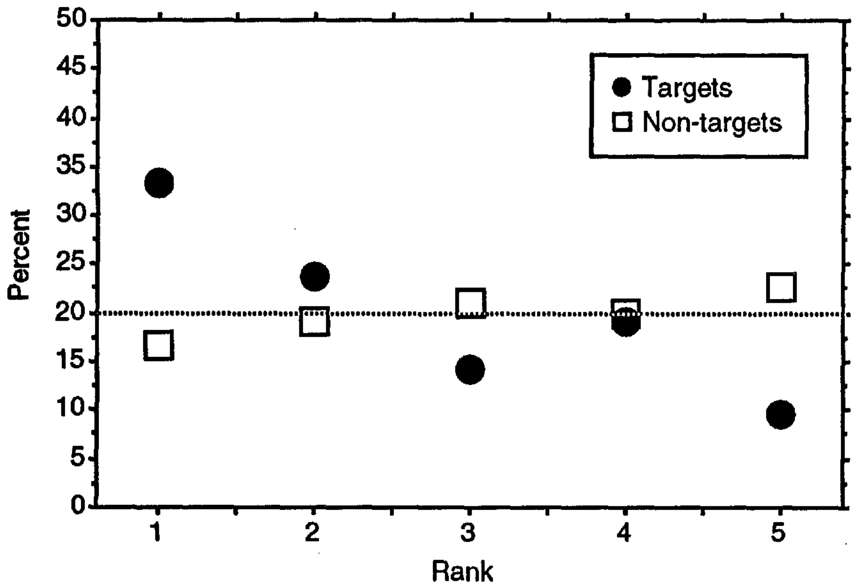

Figure 1. Rank orders for Targets vs. Non-targets. Dotted line represents theoretical (20%).

Table 3. Rank statistics by subject.

Subject	Number of Trials	Mean Rank	Effect Size	*p*	*z*
1	7	3.00	0.000	0.552	0.000
2	1	2.00	0.707	0.400	0.707
3	2	1.00	1.414	0.040	2.000
4	2	3.00	0.000	0.600	0.000
5	3	1.67	0.943	0.080	1.633
6	1	1.00	1.414	0.200	1.414
7	5	3.00	0.000	0.561	0.000

Quality scores

Table 4 shows the distribution of quality (correspondence with report) scores for the Target and Non-target groups. The median values of quality scores were higher for Targets (median=2) than for Non-targets (median=1).

The distributions of Target and Non-target quality scores (see Figure 2) significantly differed (Kolmogorov-Smirnov test, $p<.05$; Mann-Whitney U-test, $z=2.14$, $p<.03$). Compared to Non-targets, Targets were 3.4 times more likely to be rated 3 ("...contact with the site.") or above (Targets: 10/21=48%; Non-targets: 12/84=14%; Fisher's Exact Test, $p=.0019$).

Table 4. Distribution of Quality Scores for targets and non-targets.

Quality	Target N	% Targets	Non-target N	% Non-targets
0	5	24%	30	36%
1	4	19%	21	25%
2	2	10%	21	25%
3	6	29%	6	7%
4	1	5%	5	6%
5	1	5%	0	0%
6	1	5%	1	1%
7	1	5%	0	0%

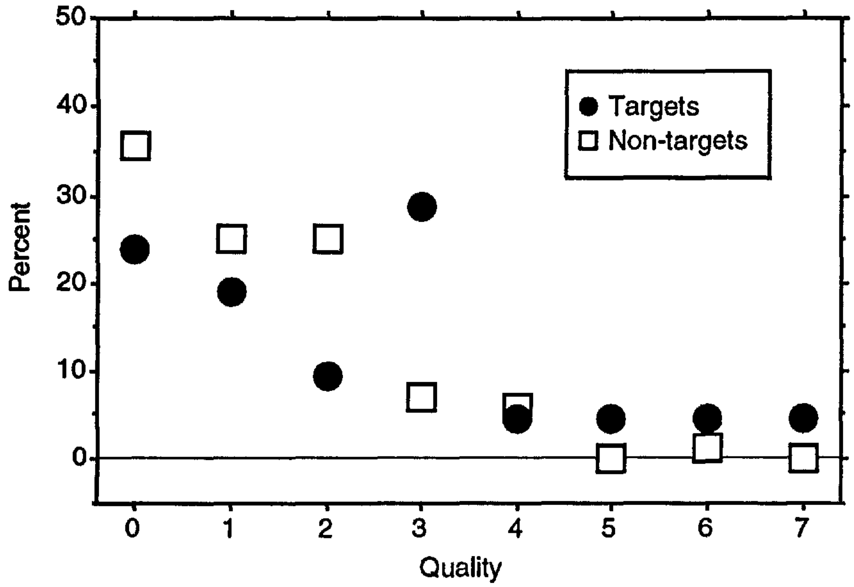

Figure 2. Quality Scores: Targets vs. Non-targets.

Three of the four RV subjects produced target viewing reports scoring 3 or better on quality, as did all three of the LD subjects. The sample size is too small to allow comparisons between the two groups.

Discussion

This study of the ability of people to report details of an unknown visual target examined remotely during the lucid dream state has shown promising results. The correspondence between the images of targets viewed in dreams and the actual target photographs was frequently enough greater than expected by chance to suggest a genuine transmission of information. The moderate to large effect sizes obtained in this preliminary study compare favorably to those acquired in other investigations demonstrating the remote viewing phenomenon (E. May & W. Luke, personal communication, 1992).

The sample size for this experiment was too small to be the basis for conclusions about the effectiveness of RV attempts in waking versus lucid dreaming. It can be said, however, that the lucid dream state allows access to this type of anomalous cognition. An example of a top ranking, high quality target "hit" will serve to demonstrate the nature of information acquired through AC in a lucid dream.

This trial was by a skilled lucid dreamer (S5) with no prior experience as a remote viewing subject. He slept with the target envelope in his bedroom. His report states,

"I realized I was dreaming [because X and Y were there; actually they are in Alaska]. The dream began to fade. I spun [technique for prolonging a dream] and arrived in my bedroom. The envelope was there, thick with much tape. I tore it open and dumped the contents on the bed. There were lots of odds and ends, which I decided to ignore, looking

only for the picture. I found the black paper [included in each envelope to prevent seeing target through envelope] and a slip of paper with the picture below."

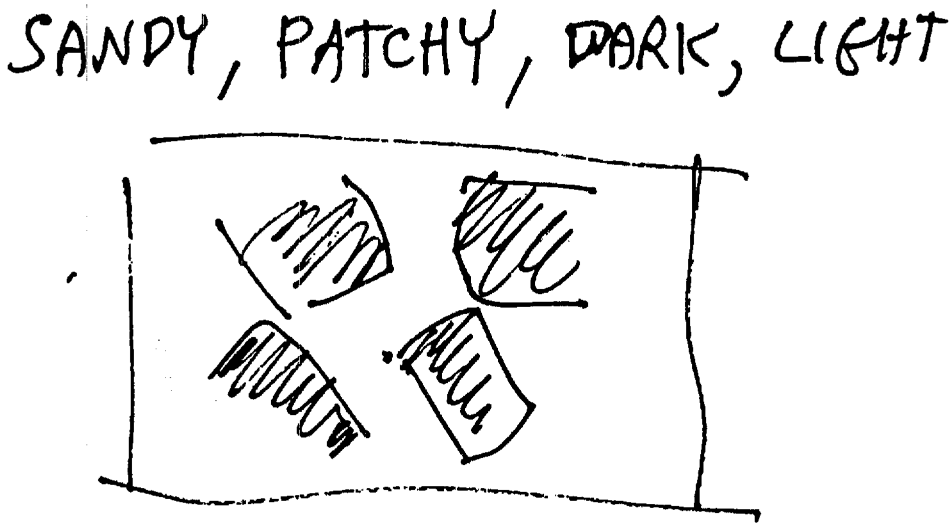

Figure 3. Report picture for target shown in Fig. 4 (S5, Trial 2).

The actual target photograph was of a high sandy dune desert with extremely contrasting patches of dark and light. The ("SANDY, PATCHY, DARK, LIGHT") pattern in the subject's drawing matches that of the target. A reproduction of the target appears in Figure 4 below.

Figure 4. Reproduction of target photo [10(4)] for report shown in Fig. 3 (S5, Trial 2).

Several indications that certain features of lucid dream RV attempts tended to accompany successful trials appeared in the content of the lucid dream reports. Among these were: veridical dream representations of the subject's bedroom and the target envelope, the augmentation of pictorial information with written words or phrases and the assistance of dream characters helping the subjects to focus on the important elements of the dream imagery. To determine if these or other aspects of lucid dreaming trials are truly important for success, future experiments will direct and organize the subject's post trial reports with standardized questionnaires.

One reason for the small sample size in this study is the difficulty of training people to have lucid dreams at home. Subjects would be likely to produce more lucid dreams when sleeping the laboratory with stimuli applied while the subjects are in REM sleep to cue them to become lucid. Furthermore, the sleep laboratory situation would enable the experimenters to awaken subjects immediately after their lucid dream trials to collect the best possible reports of the dream target viewing. Therefore, it is recommended that subsequent studies of RV in the lucid dream state be conducted in a sleep laboratory with physiological monitoring of the parameters necessary for determining sleep states. This would also permit analysis of the EEG and other physiological measures that may correlate with successful RV.

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APPENDIX F

Possible Effect of Geomagnetic Fluctuations on the Timing of Epileptic Seizures

Methods

Patients

Seizure data consisting of dates, and in some cases times and dates, of seizures were obtained for a total of 22 patients. Data for patients 1 through 17 were collected from a study of the statistics of seizure timings.[1] This data, referred to as TLG, comprised diaries of patients on a stable regimen of antiepileptic medication who recorded the daily number of seizures along with details of unusual activities, stress and alcohol consumption. In the TLG study, data from three patients was split into subsets due to medication changes, loss of data recording for a period, or intervening surgery. In this study these patients' data was treated as a unit, identically to the other patients' data, since there was no *a priori* reason to expect that the data subsets used would show a differentiation of response to GMF variations. The remaining five patient's data was collected for this study and was more heterogeneous. Patient RR1 had all seizures recorded by her parents during a 4 month period under medical supervision but prior to medication being prescribed. After being administered sodium valproate her seizures stopped. Patients NE1 to NE3 had their seizures recorded partly as in-patients and partly at home. The completeness of these recordings is not known. Finally patient WO1's seizures were recorded by a family member during two periods and are thought to constitute a complete and accurate recording. All seizures submitted were included in the analysis, except those which occurred after September 30th 1991 when *ap* index data was not available. The clinical data is summarized in table I.

Insert table 1 about here

Geomagnetic Field Data

The 3 hour geomagnetic *ap* index[16] was used as the primary measure of GMF activity. This index provides an estimate of the range of variation of the intensity of the GMF, in nT, during a 3 hour interval of universal time (UTC). The index is also a spatial average across the globe; the actual range of field strength variation observed at any location may be greater than the *ap* range at high latitudes and smaller at low latitudes. The *ap* index is an integer value in the range [0, 400] with the variance of the index increasing during magnetic storms. Since this behavior can violate assumptions of homogeneity of variance needed for *t* test used here, the *ap* index data was log transformed before the analysis. Owing to the persistence of the interplanetary particle storms responsible for the larger GMF disturbances, 3 hour and daily geomagnetic indices are auto-correlated. For instance the *Ap* daily index, consisting of the mean of the eight *ap* values for the day, has a Pearson correlation of $r = 0.48$ for data for 1980 though 1990 at one day's lag. This auto-correlation may ameliorate the effect of the lack of time of day information for some of the seizures.

Analysis

Since the majority of the seizures (3307 out of 4101) lacked time of day information, the temporal unit for the analysis was taken as a day and an index of geomagnetic activity for the day preceding the seizures was developed. The seizures for which a time of day had not been recorded were assigned to have occurred at 12 noon local time. This procedure results in a maximum error in the seizure time of 12 hours. All seizure times and dates were adjusted to UTC allowing for time zones and summer time where necessary. The average *ap* for the 24 hour period preceding the seizure was calculated by computing the mean of the (log transformed) *ap* values for the 3 hour UTC interval during which the seizure occurred and for the 7 preceding 3 hour intervals. The average daily indices for the previous days were computed similarly. The mean daily *Ap* index on the seizure day was compared with that for preceding two days with paired *t* tests of the log transformed indices. All statistical tests were calculated using SPSS-X software.

Results

GMF activity on the seizure days was compared with the activity of preceding days for the group of patients as a whole and for each patient separately. Grouping the data, the *Ap* index on the seizure day, 16.41 ± 20.2 nT, was slightly greater than for the preceding day, 16.01 ± 20.3 nT, (t [4100] = 1.84, p = 0.03). The index for the day prior to this, 16.09 ± 19.9 nT, was not significantly different from the seizure day (t [4100] = 0.55, p = 0.3). Neither was the index for the 10 days preceding the seizure, 16.43 ± 11.2 nT, significantly different from the seizure day index (t [4100] = 0.78, p = 0.2). The seizure diaries were recorded during intervals spanning the years 1977 to 1991 and covering more than one 11 year cycle of solar activity. Thus some diaries were recorded at periods of higher average GMF activity than others. For instance the mean *Ap* index for the 10 days prior to the seizure days for patient NE1 was 35.7 ± 16.9 nT, while that for TLG12 was 7.93 ± 2.1 nT. With the data combined into a single data set, GMF index changes between days will be masked by the large differences between the mean indices for the diaries. To avoid this, the differences in GMF index data between seizure and earlier days were analyzed for each patient separately. The results are shown in table II. The overall deviation from chance expectation for the group of patients can also be calculated from the individual patient's statistics by converting the t values to 1-tailed p values and then to z - scores which were combined by Stouffer's method. By this method, the *Ap* index for the seizure day was significantly greater than on the preceding day, (z = 2.48, p = 0.007) and greater, but not significantly so, than for the second day prior to the seizures (z = 1.21, p = 0.1), and for the mean daily index for the preceding 10 days (z = 1.08, p = 0.1). There is a wide range of patient t values ($-2.59 \le t \le 2.89$) present in the data. To analyze inter-patient differences, a measure of the difference in *Ap* index between the seizure days and the preceding days for each patient was defined which is independent of the number of seizures. The effect size $r = z / \sqrt{n}$ is such a measure, where z is the equivalent z - score for each patient's t value as computed above and n is the number of seizures recorded in the patient's diary. The overall effect size for the set of patients can be estimated as the weighted mean of the effect sizes and was found to be μ_r = 0.029 ± 0.016. This sample of 22 effect sizes was found to be inhomogeneous (χ^2 [21] = 33.3, p = 0.04) suggesting that the types of seizure or treatments represented in this data may exhibit intrinsically different responses to geomagnetic variations.

Insert table 2 about here

To investigate whether seizure type, sex and age of patients, or seizure frequency were significant moderating variables for the difference between *Ap* values on the seizure day, a linear regression was calculated between these variables and the patient effect size r. Using dummy variables for sex and seizure type, the regressions revealed no significant loadings for any of the variables. Given the small number of patients in the study the power of this analysis to uncover any real effects, if they exist, is small. It is perhaps worth noting that the two patients who were unmedicated for at least part of the time of seizure data collection had relatively large effect sizes (RR1, $r = 0.24$ and WO1, $r = 0.17$, $\mu_r = 0.029 \pm 0.016$).

Discussion

The hypothesized association between epileptic seizure occurrence and increased GMF activity on the seizure day was confirmed in this data. However the observed effect size for the interaction was very small ($r = 0.03$). For comparison Cohen[17] classifies effect sizes of less than 0.2 as small. Although this result has confirmed the earlier studies as regards the existence and direction of the GMF – seizure effect, the very small effect size observed and the absence of an established theoretical background for very low frequency EM fields as seizure promoters suggest that the present result should be treated cautiously. However the inhomogeneity of the sample of effect sizes suggests that there are uncontrolled factors effecting the interaction between GMF fluctuation and seizure occurrence. Whether these factors are characteristics of the patients or possibly of other environmental stimuli could not be determined in this study.

Research in neurobiology in general and epileptology in particular involves the almost impossible task of differentiating direct from indirect effects. Such unusual phenomena as seizures induced by tooth brushing or the smell of perfume but not foul odors exemplify the specificity of triggers in particular patients. Moreover, more general phenomena such as stress itself have been noted to increase the risk of seizures in many. These non-specific triggers may play only indirect roles by pathophysiologic cascades influencing neurotransmitter systems or electrical firing. Such phenomena[18] are even more difficult to determine because they may effect only a small proportion of epileptics.

These comments clearly have relevance with regard to geomagnetic influence. This could conceivably correlate with weather patterns. Cloudiness has been regarded as a possible correlate with depression. Heat intolerance can cause irritability. Indirect geomagnetic influences may turn out impossible to differentiate from direct ones but may lessen the power of tests to quantify statistically as other influences may also be confounding issues. Moreover, we know that certain patients may have their seizures triggered by events which do not influence others. Consequently, geomagnetism may play a role in a small proportion of patients and such actors as anticonvulsants may prevent this role powerfully. Thus, the profound results with the limited medicated patients may not be coincidental and serves as an excellent group for further research.

The decision not to control for anticonvulsant blood levels in our subjects merits further comment. Although serum concentrations of agents known to be pharmacologically active against seizures might appear to be the single most important variable affecting seizure frequency, there are several reasons for believing that this is probably not the case. In the majority of patients, anticonvulsant levels remain stable over time, especially when medications are administered chronically. Furthermore, except in cases of rapid medication withdrawal or extreme toxicity, there is little evidence for a one–for–one relationship between serum level and seizure frequency. Lastly, it is well known that patients respond differently at similar serum concentrations, and thus for any given concentration, some patients will seize and others will not. Furthermore patients TLG1 to TLG17 had their antiepileptic drug levels measured at least once during the study with serum concentrations within the therapeutic range. Multiple blood samples were drawn from patients TLG1, TLG4 and TLG6 and no significant changes in the serum concentrations were observed and no relation to seizure frequency could be demonstrated. We therefore could not justify the added time and expense associated with frequent serum anticonvulsant determinations in all patients.

Many avenues of further investigation exist. If the seizure promoting effect of GMF fluctuations is really due to very low frequency EM, a relationship between magnetic latitude and effect size might be expected, since the amplitude of geomagnetic disturbances generally increase at higher latitudes. Recently Randall[19] reported just such a latitude dependence in correlations between GMF disturbance and conception rate. Unfortunately the seizure data studied here come from only four locations, with 17 of the 22 patients at just one latitude. Thus the question of latitude dependence cannot be tested with this data. Another promising approach would involve studying epileptic seizures in a medical facility, where precise timings of seizures and EEG monitoring and seizure detection was possible. Such observations combined with broad spectrum measurements of low frequency EM field excursions might answer the question of electromagnetic stimulation of epileptic seizures.

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TABLE 1--CLINICAL DATA

Patient ID	Sex	Age	Seizure Type*	Medication†
TLG1	M	48	GTC	PTH
TLG2	F	40	CPS + 2° GTC	CBZ
TLG3	M	28	CPS	CBZ + VPA
TLG4	M	31	CPS	PHT + CBZ
TLG5	F	36	A	PRIM + PB + (CZP)
TLG6	M	29	CPS	CBZ + PHT
TLG7	M	4	SPS + 2° GTC	CBZ + PHT
TLG8	F	40	GTC	PHT
TLG9	M	22	CPS + 2° GTC	VPA
TLG10	F	34	SPS + 2° GTC	VPA
TLG11	M	14	CPS + 2° GTC	CBZ + VPA + NZP
TLG12	F	21	CPS + 2° GTC	CZP
TLG13	F	26	SPS	CBZ
TLG14	F	34	CPS	PHT + PB + CBZ
TLG15	M	44	CPS	PHT + PB + CBZ
TLG16	F	52	CPS	PRIM + CBZ
TLG17	F	49	CPS	PHT
RR1	F	5	A	UM
NE1	M	1	IS + CPS	ACTH + VPA
NE2	F	7	CPS + 2° GTC	DPH + CBZ
NE3	F	26	GTC	DPH
WO1	F	31	CPS	UM, VPA

*Seizure types are designated: A, absence seizure; CPS, complex partial seizure; GTC, generalized tonic-clonic seizure; 2° GTC, secondary generalized tonic-clonic seizure; IS, infantile spasms; SPS, simple partial seizure.

†Medications are designated: ACTH, adrenocorticotropic hormone; CBZ, carbemazepine; CZP, clonazepam; DPH, diphenyl hydantoin; NZP, nitrazepam; PHT, phenytoin; PB, phenobarbital; PHT, phenytoin; PRIM, primidone; VPA, Na-valproate; UM, unmedicated.

TABLE 2--SEIZURE DATA

Patient ID	Period of data col.	No. of seizures	Seizure freq.	Epoch −1* *t*	Epoch −1 *p*	Epoch −2† *t*	Epoch −2 *p*	Epoch −1 *r*
TLG1	205	7	0.034	1.03	0.17	3.10	.01	0.359
TLG2	574	320	0.56	0.70	0.24	−0.28	.61	0.039
TLG3	182	42	0.23	−2.59	0.99	−3.08	.998	−0.382
TLG4	300	13	0.043	2.08	0.031	1.85	.045	0.518
TLG5	268	1449	5.4	0.41	0.34	−0.50	.69	0.011
TLG6	370	130	0.35	0.30	0.38	−1.87	.97	0.026
TLG7	482	11	0.023	0.06	0.48	−0.23	.59	0.018
TLG8	174	7	0.040	1.20	0.14	0.35	.37	0.412
TLG9	293	82	0.28	0.55	0.29	−1.13	.87	0.060
TLG10	323	17	0.053	−0.12	0.55	0.86	.20	−0.029
TLG11	180	49	0.27	0.48	0.32	0.17	.43	0.068
TLG12	182	17	0.094	0.79	0.22	2.80	.0064	0.187
TLG13	320	101	0.32	1.81	0.037	0.44	.33	0.178
TLG14	724	133	0.18	−2.08	0.98	−2.41	.99	−0.179
TLG15	2360	768	0.33	0.61	0.27	−0.62	.73	0.022
TLG16	166	71	0.43	0.93	0.18	0.40	.35	0.11
TLG17	185	12	0.065	−0.93	0.81	−0.02	.51	0.257
RR1	111	36	0.32	1.48	0.074	2.13	.020	0.241
NE1	87	167	1.9	−0.22	0.59	−0.28	.61	−0.017
NE2	5164	109	0.021	−1.15	0.87	−1.74	.96	−0.11
NE3	563	281	0.50	1.45	0.074	3.29	.00057	0.086
WO1	62	276	4.5	2.89	0.0021	3.64	.00016	0.172

*Epoch −1 refers to comparisons between the day of the seizures and previous days.

†Epoch −2 refers to comparisons with the day 2 days before the seizure day.