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The Correlation of the Gradient of Shannon Entropy and Anomalous Cognition: Toward an AC Sensory System

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Abstract—In this study, we hoped to replicate earlier findings that have demonstrated strong evidence for anomalous cognition (AC), as well as a significant correlation between the quality of the AC with the gradient of Shannon entropy, but not with the entropy itself. We created a new target pool and a more sensitive analytical system compared with those of earlier studies. We then invited five experienced receivers (*i.e.,* experiment participants) to contribute 15 trials each. In addition to the usual rank-order analysis, two other methods were used to assess the quality of the AC. The first of these was a 0 to 7 rating scale that has been used in the earlier studies. The second, a figure of merit, was based on a fuzzy-set encoding of the targets and responses. The primary hypotheses were (a) that a significant correlation would be seen between the figure of merit quality assessment and the gradient of Shannon entropy for the associated target and (b) that the correlation using the rating assessment would be consistent with earlier findings. A secondary hypothesis was that the figure of merit quality would not correlate with the entropy of the associated target. All hypotheses were confirmed. Our results are part of the growing evidence that AC is mediated through a sensory channel.

Keywords: anomalous cognition — pattern analysis — entropy gradient

Introduction

Lantz, Luke, and May (1994) reported on two experiments, the first of which was conducted in 1992, to test sender condition and target type in an anomalous cognition (AC) experiment. The hypotheses in these studies addressed whether a sender is necessary for AC information transfer and whether AC performance differs when the targets are static photographs or dynamic material, such as videotape.

Lantz, Luke, and May (1994) found that a sender is not a necessary component in a successful AC experiment and that the data supported, but not significantly, a target-type preference in favor of static material. Because there were no significant interactions in a 2 × 2 analysis of variance (ANOVA), the data were combined across the sender versus no-sender condition. Blind ranking achieved a sum-of-ranks for the static targets of 265 in which the chance expectation was 300, leading to an effect size of 0.248 and $p = .007$. The analysis of the 100-trial dynamic targets led to a sum of ranks of 300, an effect size of 0.000, and $p = .500$.

A second experiment was conducted one year later and was also reported in Lantz, Luke, and May (1994). In that study, a sender was not used, and the protocol differed considerably from the first experiment. Four participants contributed a total of 45 trials in two target-type conditions, leading to a combined effect size of 0.550 for the static targets and the same value for the dynamic ones.

Lantz, Luke, and May (1994) discussed the apparent contradiction between the results of their two studies. They speculated that the static targets were better in their first study because of a lack of content parity between the static and dynamic targets. Nonetheless, this does not explain the similarity between static and dynamic targets in their second study. In addition, their results are inconsistent with those of some of the Ganzfeld research regarding static versus dynamic targets. Bem and Honorton (1994) found that dynamic targets produced better results in the Ganzfeld experiment than did static targets.

The data from both of Lantz, Luke, and May (1994) studies were analyzed to investigate whether AC performance depended on the gradient of Shannon entropy of the targets (May, Spotiswoode, and James, 1994a). This idea arose from our laboratory's anecdotal evidence that AC functioned particularly well when targets were especially dynamic. That is, when targets involved large changes of energy—entropy, such as underground nuclear explosions, particle accelerators, or rocket launches. In several instances, AC was outstanding when targets underwent massive changes in energy or entropy in a very short period of time during the session. Bem and Honorton's finding is also suggestive that an entropic change in the target might lead to better results. As a possible explanation for these observations, consider that AC may be mediated through a specialized sensorial system and that this system might behave similarly to the five known sensorial systems. We might reasonably expect, then, that AC would correlate positively with the changes of the sensor-input signal and correlate less well with the level of the sensor-input signal itself. In vision, for example, the system is sensitive to changes in brightness across the field, but relatively insensitive to the absolute level of illumination. Analogously, we hypothesized that the AC system might be sensitive to changes in the level of information content across a target, but insensitive to the absolute level of that measure.

In the first experiment, May, Spotiswoode, and James (1994a) found a significant correlation between the gradient of the Shannon entropy of the target and the quality of AC (Spearman rank-order correlation coefficient, r_S, of .452, $df = 26$, $t = 2.58$, $p = 7.0$ (10) for static photographic targets. Unfortunately, with dynamic targets, there was little evidence of AC and a resulting small correlation with the gradient of the entropy. In the second experiment, they found strong evidence for AC in both static and dynamic targets and for the two target types combined, the correlation between AC performance and entropy gradient r_s was .337, $df = 31$, $t = 1.99$, $p = .028$. As predicted, the correlation with the entropy itself was considerably smaller ($r_s = .234$, $t = 1.34$, $df = 31$, $p = .095$). The correlation for the combined static targets from both studies was $r_s = .161$, $df = 41$, $p = 152$. Because of the different target systems and protocols in these studies, the results remain somewhat ambiguous. This report provides a detailed description of an experiment to replicate May, Spotiswoode, and James (1994a) entropy findings.

Hypotheses

The primary hypotheses were:

- A significant correlation exists between the quality of AC, as measured by a fuzzy-set technique, and the gradient of Shannon entropy of its associated target.
- The correlation of the gradient with the quality of AC as measured by the upper half of the rating scale shown below in Figure 2 will be consistent with the static target correlation seen in the earlier experiments (May, Spotiswoode, and James, 1994a).

The concept of fuzzy sets was first applied to the analysis of AC data by May *et al.* (1990). A fuzzy-set definition of a target is similar to the commonly used descriptor lists in which an analyst is asked to ascribe the presence or absence of each element in a list of items. Instead of a forced yes or no to the presence of an element, such as water, a fuzzy approach allows for a quantitative coding of a subjective impression. For example, water might be 30% visually impacting in a target and therefore is coded as 0.3 rather than either 1 or 0. A response is coded in a similar way.

Three quantities are defined from the fuzzy-set representation of a target and a response. The *accuracy* is defined as the percent of the target that was described correctly; the *reliability* is defined as the percent of the response that was correct; and *the figure of merit* is defined as the product of the two. Because the fuzzy-set measure is less granular than a rating measure, being a rational rather than an ordinal scale, we chose it as the primary measure. The rating scale correlation was included as a historical link to our earlier experiments. A more detailed description of the technique can be found in the AC Data Analysis Section, below.

We also hypothesized that the correlation of the figure of merit with the total entropy of the target would be much less than the correlation with the gradient of the entropy.

Experiment Protocol

In contrast with the majority of our earlier AC studies, we designed a protocol in which the receivers were physically located from 5 to 4,500 km from the laboratory. In addition, many aspects of the experiment were handled automatically by two separate computers.

Target Pool Construction

For this experiment, we developed a completely new target pool based exclusively on the Corel Stock Photo Library of Professional Photographs. This library of copyright-free images is provided in digital form and comprises 100 images on each of 200 CD-ROMs. Each image is approximately 18 MB in size, which corresponds to a landscape format picture of 3200 × 1875 pixels in 24-bit color. Corel also publishes a booklet of thumbnail images of the complete set.

Selection Criteria

The first stage in constructing the target pool consisted of creating a design specification of the type of photographs that would qualify as a potential AC target. Based on earlier experience (May *et al.*, 1990), we adopted a series of a guidelines. First, the photographs had to possess common properties.

- Thematic coherence: Each photograph had to be a real scene, as opposed to a collage. Where possible, the photographs also possessed elements that could be sketched easily.
- Size homogeneity: The photographs did not contain any surprises with regard to size. For example, there would not be a photograph of a brick followed by one of a mountain range.
- Pool coherence: All of the photographs would depict outdoor scenes.

The following elements would not be included in the pool by construction or by photographic editing:

- People
- Transportation devices (*e.g.,* boats, cars, *etc.*)
- Small human artifacts (*e.g.,* tools, toys, *etc.*)

We made every effort to remove these kinds of items, although they may have been present in some photographs. If so, they were difficult to see and were insignificant relative to the rest of the scene. Finally, we would not allow odd camera angles, unusual or distorted perspectives, or odd or unusual lighting conditions.

Aside from the above restrictions, the target pool photographs could show any scene at any location. Following these guidelines, we rejected approximately half the original set of 20,000 photographs by visual inspection of the thumbnail images.

Our long-standing earlier target pool consisted of 100 photographs divided into 20 packets of five dissimilar images each. In that pool, a target for a trial was determined by first choosing a random integer between one and 20 to select a packet and then choosing a random integer between one and five to select a target. The remaining four targets within the selected pack then served as decoys for a blind analytical assessment by rank ordering.

For the development of this new pool, we chose a different approach. Namely, the analysis decoy target images would be determined after the AC trial was complete. To assure that we could do this in a blind and algorithmic fashion, we adopted a hierarchical design of groups, categories, and images. A group consisted of five categories, and each category contained five images. The images within a category would be as much alike each other as possible, although they must be of different scenes. Differing perspectives of the same scene were not included. Thus, a single category of "waterfalls," for example, would contain five similar, but different, waterfalls. In contrast, we made every attempt to choose categories within a group to be as different from one another as possible, to make them orthogonal in other words. For example, we would not have a "river" category in the same group as a "waterfall" category. The number of different groups was determined by the remaining 10,000 images that survived the first cut.

Two laboratory personnel examined all 10,000 images on a high-resolution computer display, and approximately 800 candidate photographs met the above acceptance criteria. After some digital editing, we identified from this set of 800 photographs 12 groups of 25 images for a total of 300 targets. Table 1 shows the categories that were identified for each of the 12 target groups. No attempt was made to force the categories to be orthogonal across groups.

Figure 1 shows an example of the digital editing of an image that was not selected as part of the pool to illustrate the capability to modify an image to conform to the construction guidelines. In the temple scene, nearly all the people were removed by making reasonable guesses as to what the image would have

TABLE 1
Categories for Each Target Group

	Category				
Group ID	1	2	3	4	5
1	Bridges	Canyons	Cities	Structures	Waterfalls
2	Bridges	Cities	Fields	Mountains	Structures
3	Bridges	Lakes	Mountains	Structures	Towns
4	Bridges	Mosques	Mountains	Roads	Waterfalls
5	Bridges	Churches	Deserts	Mountains	Pyramids
6	Fields	Islands	Roads	Ruins	Waterfalls
7	Cities	Coasts	Deserts	Waterfalls	Windmills
8	Coasts	Fields	Lighthouses	Mountains	Rivers
9	Buildings	Coasts	Pyramids	Vineyards	Waterfalls
10	Buildings	Coasts	Fences	Lakes	Rocks
11	Fields	Structures	Rivers	Ruins	Streets
12	Coasts	Mountains	Roads	Ruins	Towns

Note: All Structures in the table represent Asian structures

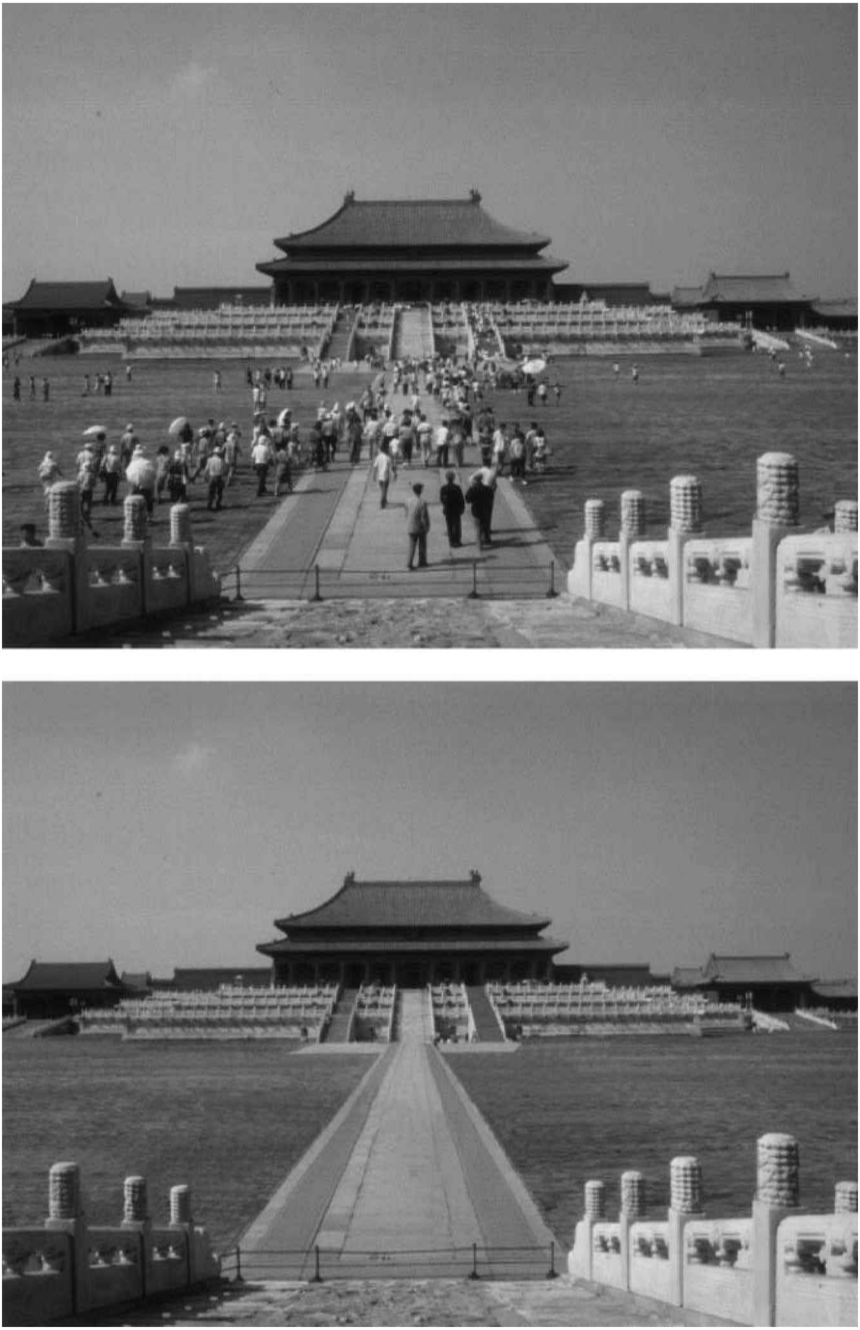

Fig. 1. An example of digital editing.

TABLE 2
Universal Set of Elements (USE)

Buildings	Coliseums	Glaciers, ice, snow
Villages, towns, cities	Hills, cliffs, valleys	Vegetation
Ruins	Mountains	Deserts
Roads	Land–water interface	Natural
Pyramids	Lakes, ponds	Manmade
Windmills	Rivers, streams	Prominent, central
Lighthouses	Coastlines	Textured
Bridges	Waterfalls	Repeat Motif

been behind each individual. As the final step in preparing an image for the target pool, the picture was cropped, if necessary, and resized to 800 × 600 pixels, each having 24 bits of color information.

Fuzzy-Set Encoding

To facilitate subsequent computer analysis of AC trials, the images were encoded using a system of descriptive elements. Each element was assigned a fuzzy-set membership value for each image. We created a universal set of elements (USE), including 50 elements that we selected from the original set of 131 elements used in our earlier work (May *et al.,* 1990). We also added elements for features that were unique to this particular set of photographs. Six individuals each coded all 300 images against this USE. As in earlier work, the coding criterion was the degree to which each element was visually impacting to the general scene. The range of visual impact ran from 0 to 1 in steps of 0.1. For example, in the bottom image in Figure 1, we might code 0.6 for "buildings" and 0.3 for "repeat motif."

The principal investigator selected 24 elements out of the 50 and qualitatively condensed the scorings from the six coders to a single "consensus" fuzzy-set representation of the targets. These 24 elements were selected on the basis of extensive experience, as well as on the formal analysis of a single study. The principal criterion used in the selection was that the elements should not be too "low level" such as lines and geometric shapes, nor should they be too "high level" such as and office building. These 24 elements were an attempt to strike a compromise between these two extremes. Table 2 shows the 24 elements that comprised the final fuzzy-set USE.[1]

Receiver Selection

Five experienced receivers participated in this experiment. They were chosen on the basis of their availability, their willingness to participate in a

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[1] A detailed description of the target pool construction and its associated fuzzy-set encoding is currently being considered as a separate paper.

lengthy AC study, and especially on their previous and sustained superior performance.

Number of Trials

The total number of trials for this study was 75 (*i.e.,* 15 for each receiver) and was determined, in advance, by receivers' availability and statistical power considerations. We used the average effect size of 0.550 from a previous similar experiment (Lantz, Luke, and May, 1994) to compute a statistical power of 68% to reach significance (*i.e.,* $p = .05$) for a single receiver and a power of 99% to reach a significant study.

Trial Protocol

We designate Experimenter 1 and Experimenter 2 as E1 and E2, respectively. E1 was located in the laboratory in Palo Alto, California, and E2 was located in a laboratory in Los Angeles. The complete target pool was independently installed on E1 and E2's computers. Note that all communication between E1 and E2 occurred only by e-mail. At a prearranged scheduled time, the following events took place in the order shown:

- E1 requested that E2 generate a target for the upcoming trial.
- E2 invoked a computer program that first randomly selected one of the 12 groups, randomly selected one of the five available categories in that group, and then randomly selected a target image from within that category of five images. The program saved its choice to a binary file and did not notify E2 about any aspect of the selection.
- E2 notified E1 that the selection process was complete.
- E1 telephoned the scheduled receiver and acted as a monitor for an AC session lasting from 5 to 15 minutes. The receiver drew and wrote the impressions and faxed them to E1 at the end of the session.
- E1 requested that E2 generate a decoy set. E2 invoked a second computer program that read the binary file containing the target information and randomly selected a target image from each of the four remaining categories from within the selected group. The four decoy target numbers and the intended target number were randomly ordered and then automatically e-mailed to E1.
- E1 analyzed the session and e-mailed the results to E2. At this point, nobody was aware of the selected target, and the analysis was complete before the receiver obtained feedback.
- E2 invoked a third program that read the original binary file and e-mailed the actual target number to E1.

- E1 posted the target photograph on a Web-site to which only the receiver had access and then telephoned the receiver to provide verbal feedback and to prompt the receiver to access the Web-site for visual feedback.

All transactions were logged, and session and analysis details were automatically stored in a database. Typically, such a trial would be complete in 30–60 minutes. Furthermore, in contrast to our earlier studies, the analysis was completed on each trial before anyone was aware of the intended target.

AC Data Analysis

We had decided to perform three separate analyses on the AC data. The first of these was a standard rank ordering of the target pack, which consisted of four decoys and the intended target. E1 was presented with the words and drawings along with the target pack associated with the trial, and the task was to rank order the targets from the best to worst matches to the response. After all N trials were analyzed for a single receiver, a continuity-corrected effect size omputed as:

$$ES = \frac{(3 - R_{\text{ave}} - 0.5/N)}{\sqrt{2}},$$

where R_{ave} is the average rank over the N trials, and the last term in the numerator is a continuity correction for small N. The z score associated with this effect size is given by:

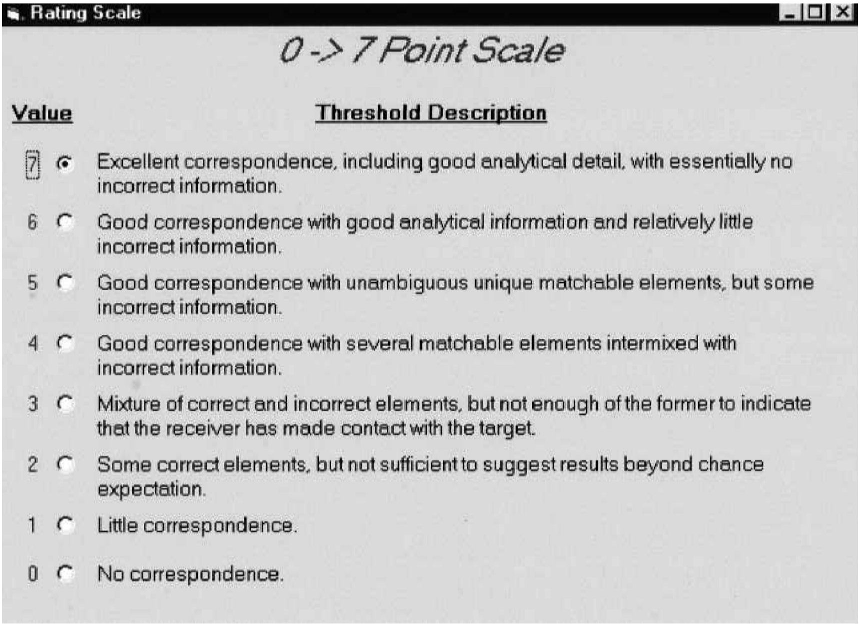
$$z = ES \times \sqrt{N}.$$

The rank-order analysis was designated, in advance, as the primary indicator of AC in the study.

Because, the primary goal of the experiment was to explore the relationship between the gradient of Shannon entropy and the quality of the remote viewing, we performed two additional analyses. Lantz, Luke, and May (1994) showed that assessing AC performance by rank ordering was not optimal for correlation studies for two reasons. First, the rank number is strongly dependent on the degree to which the photographs in the analysis pack are different from one another. Second, the ranking method discards information about the absolute quality of the match; it only describes the relative closeness of the match in comparison to the decoys. Consequently, a perfect match between a response and a target would be assigned the same first-place rank as a response that corresponded far less closely but nonetheless was sufficient to allow the analyst to assign a first-palace match.

For historical reasons and for comparison with earlier entropy experiments, we used a slightly modified version of the 0 to 7 rating scale. Figure 2 shows a screen capture image of the scale that was presented to E1 during the analysis.

To be assigned a given assessment value, the correspondence between target and response must meet one of the criteria shown in Figure 2. As before (May,



0 -> 7 Point Scale

Value		Threshold 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 not enough of the former to indicate that the receiver has made contact with the target.
2	○	Some correct elements, but not sufficient to suggest results beyond chance expectation.
1	○	Little correspondence.
0	○	No correspondence.

Fig. 2. The 0 to 7 Assessment Scale.

Spotiswoode, and James, 1994a), the scale was divided into two sections; an assessment of four and above indicating possible AC contact with the target and three and below indicating no contact.

We recognized a number of difficulties with the rating scale. The assessment values are granular, that is, they are integers with no possibility of values in between. More important, the scale does not account for the amount of material in the response. For example, the response could be simply the word “city” and receive a value of 7 for the match to a city target, even though there might be many elements, such as a river, a bridge, and mountain background, in addition to the city in the target.

Because of its extensive previous use, this rating scale was included in the analysis but defined only as a secondary measure to be used in the entropy correlation analysis. The primary measure of the absolute correspondence of a response to its intended target was the fuzzy-set based figure of merit; whereas the rank-order statistic was used as the primary measure for overall AC.

May *et al.* (1990) provided a partial solution to the problem associated with the rating scale through the use of fuzzy sets. We used a fuzzy-set measure for an assessment of the degree of correspondence between a response and a target. We defined the figure of merit (FM) as the accuracy times the reliability. The accuracy is the percentage of the target image elements that were described correctly, and reliability is the percentage of the response elements that were correct. Although neither accuracy nor reliability alone is a sufficient measure of AC, the product of the two is. Formally, the accuracy is defined by:

$$\text{accuracy} = \frac{\sum_{j=1}^{N} \min(T_j, R_j)}{\sum_{j=1}^{N} T_j}, \qquad (0 \leq \text{ accuracy } \leq 1)$$

where N is the number of elements in the USE. Similarly, reliability is defined by:

$$\text{reliability} = \frac{\sum_{j=1}^{N} \min(T_j, R_j)}{\sum_{j=1}^{N} R_j}, \qquad (0 \leq \text{ reliability } \leq 1)$$

where T_j and R_j are the fuzzy-set membership values for the target and response, respectively. Min(T_j, R_j) means the minimum of the two quantities. The figure of merit (FM) is the accuracy × reliability.

The fuzzy-set analysis for each trial occurred as follows. After the response was received by fax and while blind to the target, E1 scored each element in Table 2 as to the degree to which that element was contained in the response. If the response contained the word "waterfall," then by definition, the waterfall element would receive a score of one. If, however, there was a vague sketch that might look slightly like a waterfall, then that element might only be scored as 0.3. Thus the entire USE was scored before E1 was shown the analysis target pack.

E1 then displayed five targets for the trial, performed the rank ordering, the 0- to 7-point scale assessment, and finally entered the two target-dependent fuzzy-set elements. All results were inserted into a database for subsequent analysis.

To summarize, the fuzzy-set elements for the targets were assigned, before the experiment, to represent the degree to which each element was visually impacting in the scene. The response elements were scored as to the degree to which the element was contained in the response. At this time, we have little evidence that a receiver is capable of not only recognizing that an element is in a target but also capable of determining its visual impact. For example, we rarely received a statement such as, "There is a river in the target but it is hardly noticeable." Thus, the target fuzzy-set encoding contained more information than could be obtained easily with AC.

At this stage of our understanding of AC, we must be content with a simple recognition on the part of the receiver as to the presence or absence of a particular element. Therefore, before the calculation of the accuracy, reliability, and FM, we converted the target fuzzy set to a crisp set, containing only 1 for presence and 0 for absence for the membership values of the elements in the USE.

This process is called an alpha cut in fuzzy-set parlance. That is, we specify a threshold for the fuzzy-set membership value so that if an element is equal to or above that threshold, it is converted to a 1 or set to 0, otherwise. We adopted the threshold value of 0.2 to remove some of the noise "clutter" of 0.1-encoded elements. This value was empirically determined as a reasonable value (May *et al.,* 1990). An alpha cut was not applied to the response because the fuzzy element represented the degree to which the analyst felt that the given element was represented in the response.

Finally, we added two additional elements, which were independently scored for each target in the analysis pack, to the USE shown in Table 2. The element "visual" was an assessment of the degree to which the drawings, independent of the labels or other written material, matched a target image. The element "analytic" was the degree to which the written material, independent of the drawings, matched a target image. By definition, these elements were scored as 1 for all targets and were added to the consensus-scored fuzzy-set representation of the targets. Thus, in the equations for accuracy and reliability, N is equal to 26, with 24 elements coming from Table 2 and two coming from these additional elements.

Entropy Analysis

An entropic analysis of a photographic image is an assessment only of intensity patterns and does not include any cognitive information. In this context, the gradient means transitions between light and dark regions. The details of how such an analysis is conducted can be found in May, Spotiswoode, and James (1994a). We will, however, summarize the approach here. The Shannon entropy for a single color plane with a depth of eight bits is given by:

$$S = -\sum_{j=0}^{255} p_j \log_2 p_j,$$

where p_j if the probability of observing an intensity value of j. The following discussion holds separately for each of the three color planes. The total entropy is the sum of the three color entropies. We computed this entropy for all targets in the following way:

Each image was divided into $m \times n$ patches where we constrained the patch size to be evenly divisible into 800 and 600, the standardized target size. The patch sizes chosen were 4, 8, 20, 40, and 100 pixels square. For a given size, we computed the entropy for each patch across the photograph. For example, using a patch size of 20, we would compute the entropy for each of the 40×30 different patches. The p_js were determined by the empirical values contained in each patch. Finally, using standard numerical techniques, we computed the average absolute magnitude of the gradient[2] in this 2-dimensional entropy

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[2] The gradient is a formal measure of the "steepness" of the "hills" and "valleys" in the entropy space.

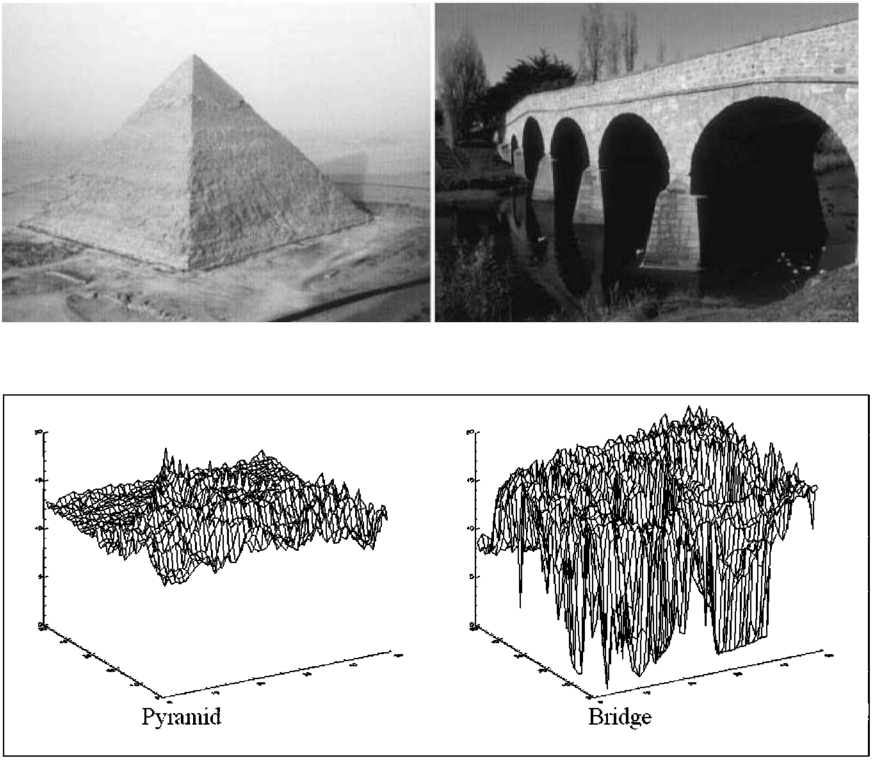

Fig. 3. Low and high entropy gradient images (top). Entropy per patch for two images (bottom).

space. Figure 3 shows images that have low entropy gradient, such as a pyramid and those that have high entropy gradient, such as a bridge.

Both entropy plots have the same vertical scaling of 20 bits.[3] The steeper gradient of the "hills" and "valleys" in the bridge plot results in that image having 365% greater entropy gradient than the pyramid image has.

The entropy gradient calculation was performed for all of the patch sizes shown above for all targets. Additionally, we calculated what we call the total entropy in which we computed a single value for the entire picture. That is, the single patch size was 800 × 600. All results were stored in the database for later analysis.

Correlation Analysis

To closely approximate the patch size that was used in our earlier studies (May, Spotiswoode, and James, 1994a), we adopted a patch size of 20 × 20 as

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[3] The maximum entropy is 24 bits, given that the sum is over all three 8-bit color planes.

the primary value for the correlation calculations. We did, however, examine any effects as a function of patch size. Similarly, we divided the assessment scale in half and used only the upper half for the correlation calculations, but we examined any effects as a function of scale division.

For the correlation of gradient and entropy with the rating scale, we used the conservative, nonparametric Spearman's r method and converted the observed correlation to a standard normal deviate with Fischer's Z transform. The FM values are more nearly continuous as a consequence of its algorithm. Nonetheless, even in this case, we used the more conservative Spearman's r to compute the correlation.

Results

The results fall into the two categories of evidence for AC and correlation effects. All p values are quoted as single-tailed.

AC Results

Table 3 shows the average rank, continuity-corrected effect size, and associated p value for the five participants' 15 trials.

The results, using the rank-order statistic, illustrated in Table 3, show no AC in this study either for individual receivers or overall. The effect size falls below what we have come to expect from this group of receivers. We shall return to this point in the Discussion section. Note that the effect size for the total is not the average of the effect sizes for the individual receivers. This is because, taken as a study with 75 trials, the continuity correction is different.

Entropy Results

For our primary hypothesis, which requires a correlation test with the figure of merit, we find a Spearman's r for the average magnitude of the gradient of Shannon entropy correlated with the figure of merit of 0.212 with 73 degrees of freedom. This corresponds to $Z = 1.83$, $p = .034$. Figure 4 shows the scatter diagram for the gradient versus the figure of merit.

Although the sum-of-rank statistic did not show significant evidence for AC, the primary hypothesis was confirmed. That is, the quality of the AC as

TABLE 3
AC Results

Receiver	Average Rank	Effect Size	p value
8	2.867	.070	.392
127	3.267	−.212	.795
221	2.933	.024	.463
497	2.933	.024	.463
937	2.933	.024	.463
Totals	2.987	.004	.486

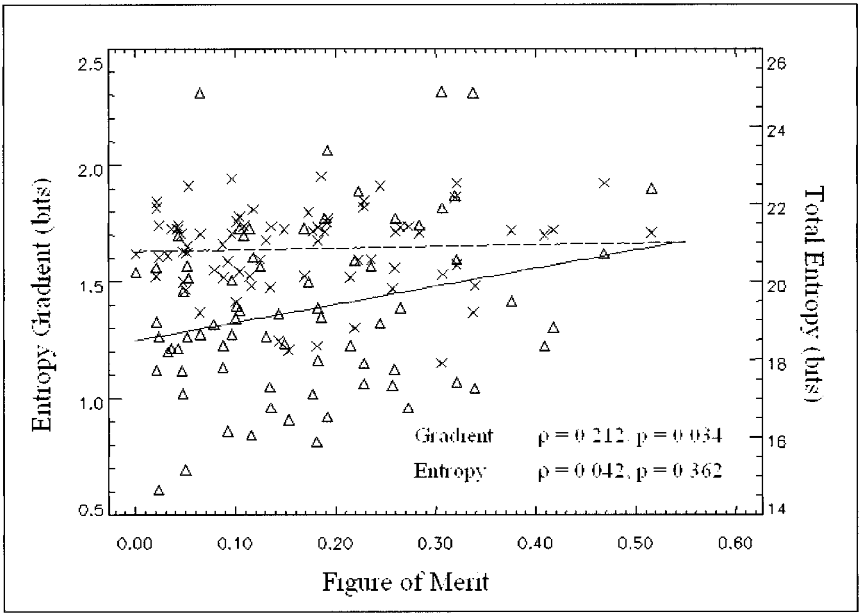

Fig. 4. Correlation of FM with entropy and its gradient.

measured by the figure of merit significantly correlated with the gradient of Shannon entropy for a patch size of 20. The points for the gradient are shown as Δ, and the regression line is shown as the solid line in Figure 4.

Next, we examined the correlation of the gradient of Shannon entropy with the assessment scale with values greater than three. With a patch size of 20, this correlation most closely replicates the earlier work.

The second hypothesis was also confirmed. The combined static target results from the previous two studies produced a strong correlation ($r_s = .161$, $df = 41$, $p = .152$). In this study, as measured by the upper half of the rating scale as shown in Figure 2, the gradient of Shannon entropy did correlate with the quality of AC ($r_s = .146$, $df = 23$, $p = .246$) at nearly the same level as before.

Finally the secondary hypothesis was confirmed as well. The correlation between the total entropy and the figure of merit was small ($r_s = .042$, $df = 73$, $p = .362$). The points for the entropy are shown as × in Figure 4, and the regression line is shown as dashed.

Discussion

AC Result

Utts (1995) has shown that our experienced receivers exhibit a consistency of AC effect size over time, a result consistent with our own observations. Because of this, we have come to expect significant results when, as in this study, we have sufficient statistical power to observe a significant result. When a study fails to exhibit significant evidence for AC, we are usually suspicious that some aspect of the protocol was responsible for the decrease in study effect size.

There were several protocol differences between this study and our usual method: a new target pool was used, the primary analysis was completed before feedback was given, and the subjects were physically remote from the lab. We do not expect that the first two points are a factor, but the last probably is. This is not to suggest that distance between target and receiver is a modulating variable. Rather, we suggest that it is a matter of attention to the task. In the past, we have invited our receivers to the laboratory for their sessions. Many times, this involved flying them across the United States for a weeklong visit on two or three separate occasions. In these cases, when a receiver was present in the laboratory, they had our full attention for the trial. All activity in the laboratory was focused on that single trial.

In this study, the monitor called each receiver at a prearranged time and conducted a short session by telephone. The trials therefore amounted to relatively brief interludes in the otherwise busy schedules of both the receivers and the experimenters. These are psychological conditions unlike the intense focus during trials in our earlier studies. There are numerous laboratory anecdotes about excellent AC performance under high attention. The “Put to the Test” AC trial that was shown on national U.S. television is just one example.[4] In this example, approximately 10 people had their full attention on a trial that cost an estimated $100,000; the result was near perfect correspondence between responses and targets.

These kinds of arguments can only be speculation, of course. One of the benefits of working with the same receivers over a protracted period of time is that our observed individual performance consistency allows such speculation. In this case, all of the receivers have been participating in experiments of this nature for more than 15 years. Further studies in which the receivers are in the laboratory will test this possible explanation.

Entropy Result

Figure of merit assessment of the quality of the AC. As shown in Figure 4, we observed a significant correlation between the gradient of Shannon entropy and the quality of the AC as measured by the figure of merit. This correlation, however, was observed at a patch size of 20 × 20 pixels. A question arises about possible dependency of the correlation on patch size. Table 4 shows the patch size, Spearman’s r ($df = 73$), its associated Z score, and p value tested against $r_s = .0$.

Except for patch sizes of 40 and 100, we see a consistent correlation as a

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[4] LMNO Productions, Sherman Oaks, CA; November 28, 1995.

TABLE 4
Patch-Size Dependence

Patch	Spearman's r	Z Score	p Value
4	0.218	1.879	0.030
8	0.218	1.879	0.030
20	0.212	1.828	0.034
40	0.121	1.035	0.150
100	0.079	0.672	0.251

function of the patch size. Perhaps the decrease for the larger patches is because the details of the intensity features are lost as they become an increasing fraction of the picture. For example, consider an 800 × 600 pixel image. The patch of size of 40 and 100 correspond to 0.3% and 2.1%, respectively, of the total area. These numbers intimately depend on the details of the target pictures in the study and do not generalize.

A more important consideration, however, is to determine what other circumstances might induce an apparent correlation between the entropy gradient and the figure of merit. Because the targets were chosen randomly, the probability of matching a given response to the intended target is 20%, regardless of response bias on the part of the receiver or judging bias on the part of the analyst. In particular, analyst bias cannot systematically affect the figure of merit values because of this blind assessment. Thus, a number of potential artifacts are eliminated because of the differential match and the random selection of the target.

Nonetheless, it might be that there is some variable that correlates independently both with the gradient of the entropy and the figure of merit. One such candidate is the cognitive complexity of the target. If the gradient of the entropy correlated significantly with some measure of cognitive complexity, and the figure of merit did so as well, then the observed correlation of the gradient of the entropy with the figure of merit would contain an artifact.

As May *et al.* (1990) showed, a reasonable estimate for the cognitive complexity is the fuzzy-set sigma count for each target. The sigma count is simply the sum of the membership elements in the fuzzy-set representation of the target. The USE as shown in Table 2, represents high-level cognitive elements, whereas the USE that has been used in the past contained a large number of nonobject features such as ambiance, color, and low-level linear features. May, Spottiswoode, and James (1994a) reported a small and nonsignificant correlation of target sigma count and the gradient ($r_s = -.028$, $df = 98$, $p = .609$). In our current USE, however, the elements are all features that might contain significant intensity patterns and thus might show an overall correlation of gradient with sigma count.

As expected, therefore, for all 300 targets in the pool, we observed a significant correlation between the gradient of Shannon entropy, computed for a patch size of 20, and the sigma count ($r_s = .199$, $df = 297$, $p = 2.59 \times 10^{-4}$). For the 75 targets that were selected in the study, the correlation is larger ($r_s = .359$, $df = 72$, $p = 7.10 \times 10^{-4}$).

The correlation of the sigma count with the figure of merit is small, however ($r_s = .0017$, $df = 72$, $p = .494$). To determine the impact of these two correlations on the correlation of the gradient with the figure of merit, we consider a general case. Suppose that there is a significant correlation between variables X and Y, $r(X, Y)$. Suppose further that X and Y both independently correlate with a third variable, Z. We must determine the conditions for the magnitude of these independent correlations such that the observed $r(X, Y)$ would be an artifact. Assume that the $r(Y, Z)$ is unity (*i.e.,* completely correlated). We then can replace Z with Y and consider $r(X, Z)$ as $r(X, Y)$. In this case, $r(X, Y)$ is completely determined by $r(X, Z)$. If $r(Y, Z)$ is less than unity, than the contribution to $r(X, Y)$ from the independent correlation with Z will be smaller than in it is the unity case.

In our case, the correlation of the figure of merit with the sigma count is $r_s = .0017$ and the correlation of the gradient with the sigma count is $r_s = .217 < 1$. The contribution to the observed correlation of the gradient with the figure of merit for this potential artifact is therefore less then .0017.

Rating assessment of the quality of the AC. For historical and replication reasons, we examined the correlation of the gradient with the upper half of the blind rating scale shown in Figure 2. The Spearman's r was .146 ($df = 23$, $p = .246$), which was consistent with the combined correlation of $r_s = .161$, $df = 41$, $p = .152$ for the static targets in the earlier two studies (May, Spotiswoode, and James, 1994a).

Conclusions

The primary and secondary hypotheses were confirmed. That is, the gradient of Shannon entropy of the target appeared to correlate with the quality of AC, whereas the quality did not correlate with the entropy itself—a result that is suggestive of a sensory system.

We legitimately might ask how it is possible to see no AC in the study as defined by the accepted rank-order technique yet see a significant correlation with the gradient of the entropy. One way to understand this apparent contradiction is to examine closely the underlying assumptions of the two AC measurements that are involved, rank order and figure of merit. It is clear that the rank-order technique is a relative measure, which is strongly dependent on the orthogonality of the set of photographs in a judging pack. As an example, let us assume that the target is a small cabin next to a stream in the woods and that a minimal response includes flowing water but does not include the cabin or the woods.

In the best case scenario, suppose the pack orthogonality was such that only one picture contained any water at all. In this case, with a modest amount of

AC, an analyst would have no trouble making a first-place match. In the worst case scenario, suppose the pack contained all five pictures with flowing water of various types, but only one contained a cabin in the woods as well. In this case, the analyst would, on average, end up with a third-place match. Thus, we can see that the rank statistic for the same response strongly depends on the photographs in the judging pack.

In the figure of merit analysis of this same example, it might be that the scores for all the photographs in the worst case scenario might be identical, say 0.15, because the response matches each target with about the same level of small correspondence. But in the best case scenario, the figure of merit analysis will give the same score for the stream-cabin-in-the-woods target (*i.e.*, 0.15), but all the decoy targets will be lower. The point is that the figure of merit for the intended target is independent from the content of the judging pack.

Many trials in the best case scenario would likely yield a significant rank-order statistic, whereas in the worst case, the rank order is exactly at chance. For the small amount of AC that was assumed in the example, one might come to each of these conclusions, depending on the judging pack orthogonality.

In our case, there is no question that the AC is far below what we have come to expect from our established receivers. Second, by the nature of our target pool bandwidth (May, Spotiswoode, and James, 1994b), it is difficult to assure strong orthogonality.

In the past, these types of targets have done well when the AC functioning is strong; however, when the functioning is weak, as in this experiment, a rough threshold of AC is needed to produce a significant rank-order statistic. As we have illustrated from the example, it is unlikely that the threshold is zero. That is, small amounts of AC might still produce a rank-order statistic near chance.

A correlation is algebraically not sensitive to the absolute level of one or both of its variables. We could add a large constant to either the gradient or the figure of merit and would find exactly the same correlation.

Therefore, we believe that we have replicated the earlier finding in which the quality of AC is correlated with the gradient of Shannon entropy and not with the entropy itself. This result is part of the growing and compelling evidence that AC is mediated through a sensory channel. This might be either some combination of the known senses or an additional one. Functional brain imaging may resolve this question by allowing us to directly observe neural functioning during anomalous cognition.

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