Geomagnetic Activity and Anomalous Cognition: A Preliminary Report of New Evidence

S.J.P.Spottiswoode

ABSTRACT

Analyses of anecdotal reports of putative telepathic experiences have shown that these tend to be reported on days of relatively low geomagnetic activity. Studies of laboratory psi experiments have yielded weak confirmation of this effect. The existence of a negative correlation between scores in free response anomalous cognition experiments and geomagnetic fluctuations was confirmed in four data sets (combined $p = 3x10^{-6}$) which showed significant anomalous cognition. The negative correlation was absent from two other data sets showing no evidence of anomalous cognition. Additionally, analysis of an unusually large database of anomalous cognition trials (n = 336), covering a range of ± 130 hours between perception and target observation, suggests that the negative correlation between scores and geomagnetic fluctuations occurs only for trials in which this interval is less than ± 2 hours, and is absent for precognitive or retrocognitive perceptions outside this time range. These results may facilitate the elucidation of the physical mechanism of anomalous cognition.

INTRODUCTION

Anomalous cognition (AC), here defined as the acquisition of information about the world without the mediation of the known senses, has been studied extensively in the last twenty years. While substantial progress has been made in answering the question of AC existence, the physics of the process remains entirely obscure. Nothing is known of the medium by which the AC information is conveyed or of the receptors responsible for its acquisition by the brain. These problems have resisted investigation primarily because no physical parameters have been found which correlate with, or modulate, AC performance. Recently, however, a correlation between AC performance and very low frequency magnetic field variations has been discovered.[1] Furthermore, the correlation appears to differentiate between AC events in which information transmission and reception are approximately simultaneous and those for which transmission occurs before, or after, reception.

Since 1985 a number of retrospective epidemiological studies have reported a relationship between the state of disturbance of the geomagnetic field (GMF) and alleged spontaneous paranormal phenomena such as telepathy, clairvoyance, precognition and apparitions.[2] The most extensively studied effect concerns anecdotal reports of putative telepathic experiences concerning personal crises which have been found to occur on days of relatively low geomagnetic disturbance.[2,3,4] Examples of anecdotal reports of precognition have also been studied for which the relationship with GMF activity occurring at the time of the perception does not hold.[1] While these studies of anecdotal reports are suggestive of a relationship between extrasensory perception, or anomalous cognition (AC), and GMF activity, the uncontrolled source of the data and statistical problems of determining chance expectation for such reports[5] limits their utility.

To avoid these problems, past laboratory AC experiments, where the assessment of AC is unambiguous, have been examined for a relationship between scores and GMF activity. These analyses have yielded apparently inconsistent results with some studies yielding an effect in the expected direction of increased scores during magnetically quiet periods,[6,7] while others[8-12] have not found this. Several factors may have contributed to this.

The studies all utilized daily averages of GMF activity as the correlating variable, whereas GMF indices which average activity over a three hour period are available. These would yield a more precise measure of the GMF activity occurring at the time of the trials. Additionally most of the studies divided the AC data into subsets of high and low scoring trials; the mean GMF index of these sets was then compared. A measure of the correlation between AC scores and the GMF index at the trial time is statistically more powerful, since all the AC data is used, and an arbitrary split of the AC data is avoided. A further consideration is that if a real relationship existed between GMF fluctuations and AC scoring, this should result in the magnitude of observed correlations being an increasing function of AC effect size. In particular, AC studies with a near zero effect size should not exhibit GMF index correlations.

Finally, one of the studies[11] concerned an unusually large (n = 336) and significant ($p < 10^{-9}$) data set[13] which, however, covered a wide range of time intervals between AC and target examination by the agent. Persinger's[1-4] studies of anecdotal reports indicated that the GMF modulation of AC performance may only occur when the AC and target

event are approximately simultaneous. This data has therefore been re-analyzed with the near simultaneous trials taken separately.

METHOD

Following a request by the author for data from AC studies for which precise trial times were available, six sets of such data were received. These data sets contained the time, date, location and time zone of the AC trial as well as the score expressed either as a ranking or as a *z*-score. These studies differed considerably in design and experimental hypothesis, though they were required to be of a free response design in that they employed large target pools of complex material. Five of the six studies utilized geographic locations or pictures thereof. All of the studies, except the large series of remote viewings from PEAR,[13] were real-time in the sense that the subject's anomalous perception of the target occurred at approximately the same time as the target was being observed by a second person, or agent. In the PEAR data the interval between AC and agent observation of the target ranged from -133 to +125 hours, with most of the data falling within a 24 hour time difference. In the analysis of real time AC that follows, the subset of the PEAR data (n = 130) consisting of trials where the AC perception and target observation occurred within ± 2 hours was defined as a study unit. Two data sets from Lantz et al[14] were published in the same study, but were analyzed separately as they came from different subjects, one of whom demonstrated significant AC while the other did not. They were treated as separate study units here.

Variations in the GMF field were indicated by the *ap* geomagnetic index, a value which encodes the range of variation observed during a three hour period of the most disturbed horizontal field component of the GMF averaged over 13 stations around the world on an approximately linear scale[15]. Although the *ap* index is a global three hour average of deviations in the GMF intensity from normal levels, it represents quite accurately local field intensity variations larger than 1 nT (1 nanoTesla = 10^{-5} Gauss) in amplitude, and taking several minutes to occur.[16] For example, GMF total intensity measurements taken at 10 minute intervals at a U.S. Geological Survey station at San Juan Bautista, California covering 90 days in 1989 were compared with *ap* index values for the same period. The absolute value of the range in nT observed and the *ap* index for each 3 hour period of this data exhibited a Pearson correlation of $r = 0.78$.

Data from each of the AC study units was treated identically: AC scores were either delivered as *z*-scores or as rankings which were converted to

z-scores. The time of each trial was converted to UTC (Universal Coordinated Time), with corrections where appropriate for summer time, and the *ap* index value was found for the three hour period encompassing the time of the trial. Owing to the skewed distribution of the *ap* index data, Spearman rank order correlations (*rho*) were used throughout to calculate correlations between the *ap* index data and the AC z-scores. The observed sum squared difference of ranks, D, was compared with its expected value and variance under the null hypothesis in order to derive a *z*-score for the correlations[17]. All probability values given are 1-tailed, unless otherwise stated, on the hypotheses of AC itself and negative correlation between real time AC scores and the *ap* index at the time of AC trial. Effect sizes were calculated in all cases from the *z*-score as z/Ãn.

RESULTS

The AC results for the six study units and their correlations to GMF activity are shown in table 1. Taking the six study units as a group, there was significant AC scoring, (Stouffer's $z = 5.03$, $p = 2.4 \times 10^{-7}$) while the Spearman rank order correlation between AC *z*-scores and *ap* index score, calculated for the group by combining the six sets or data, was *rho* = -0.125 (n = 305, $z = -2.18$, $p = 0.029$). However two of the six study units, numbers 1 and 2, showed no evidence of AC (Stouffer's $z = -1.49$, $p = 0.93$) and would not *ex hypothese* be expected to exhibit a GMF correlation, which was found to be the case ($z = 0.37$, $p = 0.35$). The remaining four study units, numbers 3 though 6, exhibited significant AC (Stouffer's $z = 7.22$, $p < 10^{-10}$) and were significantly negatively correlated with the *ap* index (Stouffer's $z = 4.54$, $p = 2.8 \times 10^{-6}$).

DATA SETS IN ORDER OF INCREASING AC EFFECT SIZE SHOWING THE RANK ORDER CORRELATIONS OF AC SCORES WITH 3 HOUR *ap* INDEX

Table 1.

Study Unit #	Study Unit	n	AC *P* Value	AC Effect Size	GMF-AC *Rho*	GMF-AC *z*	GMF-AC Effect Size
1	SRI 105 [14]	40	0.96	-0.28	0.008	0.048	0.008
2	Carpenter [18]	75	0.63	-0.037	0.055	0.48	0.055

3	SRI 009 [14]	40	0.012	0.36	-0.46	-2.85 *	-0.45
4	Schlitz & Haight [19]	10	0.048	0.53	-0.70	-2.10 *	-0.66
5	PEAR (± 2 hrs.) [13]	130	5.0×10^{-10}	0.54	-0.31	-3.47 *	-0.30
6	Schlitz & Gruber [20]	10	5.8×10^{-6}	1.39	-0.22	-0.67	-0.21

(* indicates $p < 0.05$)

EPOCH ANALYSIS OF THE REAL TIME STUDY UNITS

The time dependency of these correlations was examined by means of an epoch analysis. In each study unit, rank order correlations between the AC *z*-scores and *ap* index values were calculated for each of 20 three-hour epochs both before and after the epoch containing the actual trial. Each rank order correlation was converted to a *z*-score and the *z*-scores for each epoch were then combined across the study units by Stouffer's method. In figure 1 the resulting *z*-scores for the group of four study units showing significant AC (units 3, 4, 5 and 6) and for the two study units showing no evidence of AC (units 1 and 2) are shown. Additionally, figure 1 displays the result of a Monte Carlo simulation of 10 simulated studies of 200 trials each. These simulated studies were composed of data calculated to exhibit a negative correlation with GMF activity at the time of each trial, thus creating a mathematical model of the actual correlations between AC performance and GMF activity so that the time dependency of the correlations in the two cases could be compared. In each simulated study 200 random trial times between 1/1/1970 and 1/1/1990 were calculated and the *ap* index values for these periods obtained. Simulated AC *z*-scores for the 200 trials were then calculated by a routine which assigned a normally distributed random *z*-score to each trial such that the final effect size for *ap* index correlation to trial *z*-scores was -0.32. The resulting 10 simulated studies had an mean rank order correlation *z*-score of -4.50, close to the value obtained ($z = 4.54$) for the combined set of four significant AC study units. The data for the 10 simulated studies were then processed for the epoch analysis in the same manner as the actual study units and a mean *z*-score was calculated for each of the 41 epochs.

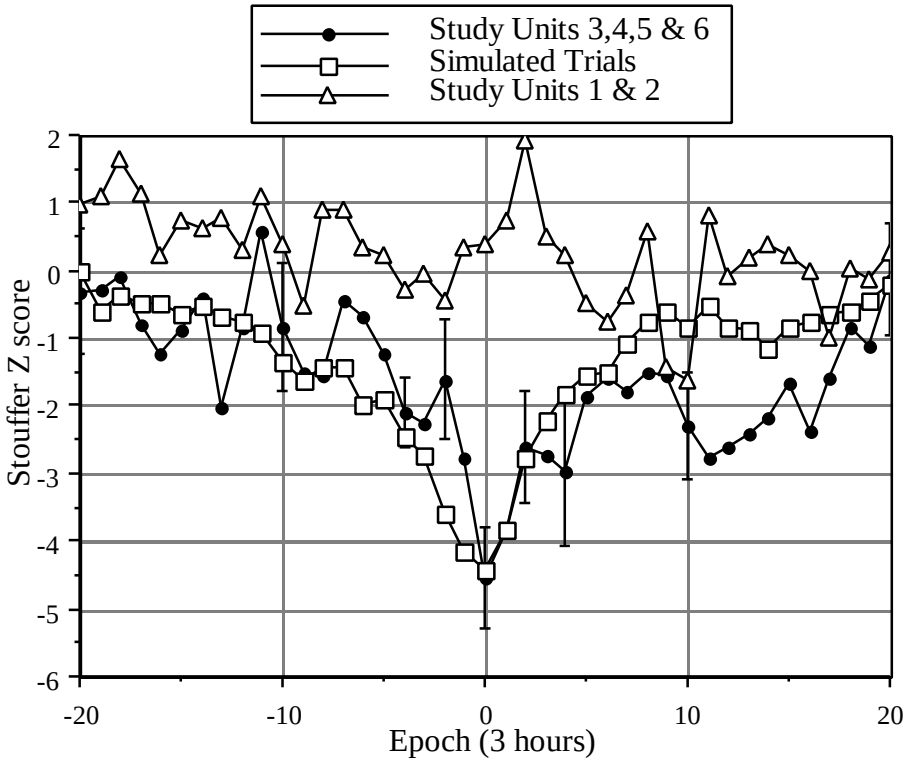

Figure 1. *Plot of Stouffer's z-scores for 4 study units exhibiting significant AC, 2 study units without AC and 10 simulated studies versus epoch (error bars of ±1 standard deviation).*

The plots for study units 3 through 6 (n = 190) and for the simulated studies (n = 2000) were similar and showed a broad peak of negative correlation centered at epoch zero. The simulated study data exhibited less variance as was to be expected given the larger number of trials. The data from study units 1 and 2 (n = 115) exceeded $|z| = 1.645$ ($p < 0.05$) twice in the 41 epochs, a result consistent with the null hypothesis. By construction, the simulated study AC data were negatively correlated with the *ap* index data at epoch zero, while the tails before and after epoch zero were due to the substantial autocorrelation of the *ap* index. For instance, for *ap* data from 1980 to 1990 the autocorrelations were found to be $r = 0.77$ at epochs ±1, $r = 0.42$ at epochs ±4, and $r = 0.20$ at epochs ±10. The Stouffer's *z*-score for study units 3 through 6 data showed a similar broad peak suggesting that the negative correlation between AC scores and *ap* index was due solely to an effect occurring at the moment of the trial. More precise estimates of the time structure of these correlations are limited by the three-hour wide averaging inherent in the *ap* index.

THE GMF TO AC CORRELATION AS A FUNCTION OF THE TIME BETWEEN AC AND TARGET OBSERVATION

The PEAR[13] data (n = 336) consisted of AC trials with a fairly uniform protocol and analysis by means of a descriptor set and analytic scoring function. This data base covered a wide range of intervals between AC and target observation by an agent and was therefore suitable for investigating whether correlations between AC scoring and GMF fluctuations were dependent upon the interval between AC perception and agent observation of the target. The PEAR data set was divided into subsets according to the agent-to-AC-perception time interval, the time limits for each subset being chosen so as to keep the number of trials in each subset greater than 20 where possible. The rank order correlation to *ap* index at the trial time was calculated as before for each time subset. The results are shown in fig. 2.

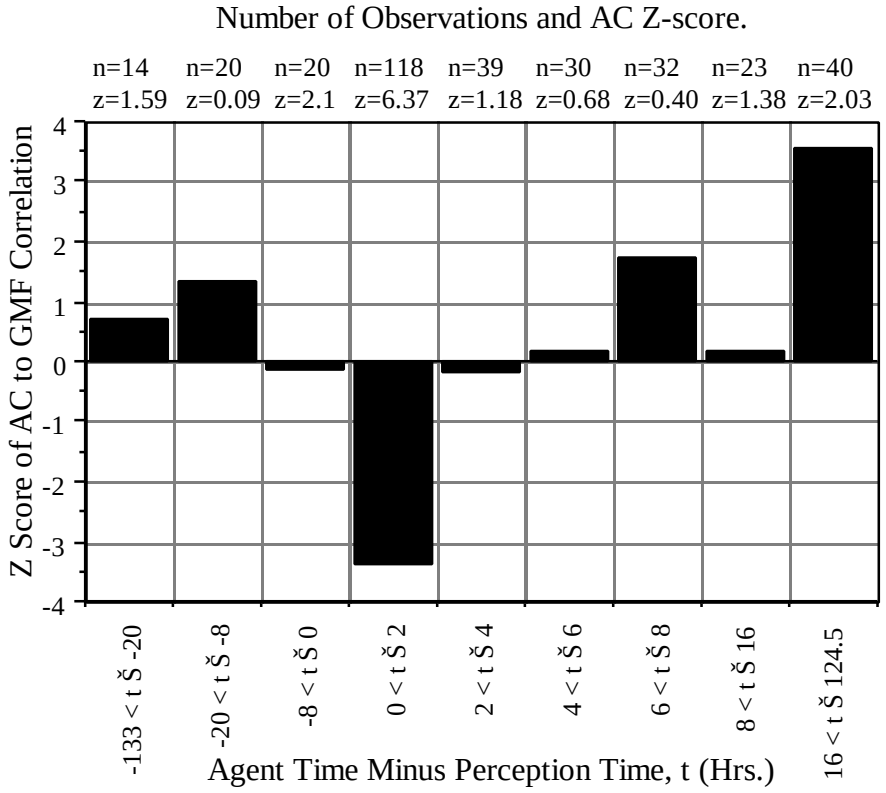

Figure 2. *Plot of z-score derived from rank order correlation between AC score and ap index versus perception - agent time interval*

In addition to the significant negative correlation observed previously between the real time trials in this data set, there were two other correlations to GMF fluctuations which reached significance. In the +6 to +8 hours subset (z = 1.74), in which there was not significant AC, and in the + 16 to + 124.5 hours subset (z = 3.54), for which the AC result was significant (z = 2.03). Taking the PEAR data outside the ± 2 hour real-time subset, the AC-GMF correlation was found to be *rho* = 0.20 (n = 206, z = 2.89, p = 0.004, 2-tailed) and there was also AC (z = 3.34). The difference between the correlations in the real-time (± 2 hours) and time displaced subsets was significant (z = 4.50, $p = 6.8 \times 10^{-6}$). It therefore appears that AC scores in non real-time trials in this data set are positively correlated with increased GMF fluctuations.

DISCUSSION

The existence of a negative correlation between scores in real-time free response AC experiments and GMF fluctuations, as registered by the three hour *ap* index, was confirmed for four data sets which showed significant AC. The negative correlation was absent from two similar data sets with no demonstrable AC. Furthermore the negative correlation appeared to apply only to trials in which the AC experience and observation of the target by an agent occurred within ± 2 hours. The negative correlation between AC scores and GMF fluctuations constitutes the first, and currently only, known physical correlate to AC performance. The absence of physical variables associated with psi functioning has hampered research into the mechanism of the information channel and the receptor responsible for AC information acquisition. It should be noted that the large amplitude (> 1 nT) and long period (> 1 min.) fluctuations encoded by the *ap* index may not be the primary physical parameter responsible for modulating the AC scoring in these experiments. The interactions between the ionosphere and the solar wind which give rise to the GMF variations registered by the *ap* index also give rise to a wide range of other electromagnetic disturbances, as well as variations in the ground level cosmic ray flux[21] and other effects. An important task will therefore be to isolate which physical variable is responsible for the variations in AC performance.

A puzzling feature of free response AC has been that the phenomenon appears to generate experimental data of approximately the same size and style of effect regardless of the time interval between AC and target perception by the agent. The discrimination of real-time from time-displaced AC, as demonstrated in the PEAR data, is the first evidence of a clear discriminant between these versions of AC. It also argues against the thesis that the GMF correlations described here are due to a

modulation of mental state variables, for instance the ability to capture fleeting imagery or to maintain the quiet internal state which is thought to be conducive to good AC performance. On this assumption the GMF effect would presumably affect real-time and time-displaced AC equally. The apparent difference between real time and time displaced AC in terms of GMF correlation may therefore reflect a feature of the physical mechanism of the channel.

Finally, the existence of correlations of the size apparent in this study should influence the design of AC experiments. Experiments in which it is desired to have the maximum possible AC effect should be timed to occur in periods of low GMF fluctuation, at least until the critical physical variation becomes known and can be specifically controlled. Furthermore, in the absence of such timing or control the GMF correlation introduces a significant variance into an AC experiment and any attempt to compare experimentally manipulated conditions should take this additional source of variance into account.

CORRESPONDENCE: S. James P. Spottiswoode, 9421 Charleville Boulevard, Beverly Hills, California 90212. Voice: (213) 276 5443. Fax: (213) 933 6476.

ACKNOWLEDGMENTS: The author thanks all those who helped to collect and deliver these data, Jim Carpenter, Ed May, Marilyn Schlitz, and particularly Roger Nelson of PEAR. My thanks also to M. Johnston of the USGS for providing their magnetometer data. Thanks also to Ed May and Jessica Utts for their many useful comments on the analysis and to Julian Isaacs, Stephan Schwarz and William Braud for their helpful suggestions and encouragement.

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ADDENDA

1. The correlations between AC *z*-scores and ap index values can also be expressed by Cohen's *d* effect size measure,[22] where *d* is derived from *rho*, the Spearman rank order correlation, by,

$$d = 2\ rho\ /\ \tilde{A}(1 - rho^2)$$

The variance of *d* can be found from,

$$var(d) = 4/(n - 4)$$

where n is the number of trials in the study.

To combine the effect sizes of k studies, for which the Cohen's *d* 's are $d_1,...,d_k$ and which have numbers of trials $n_1,...,n_k$, the combined effect size d_c is given by,

$$d_c = w_i\ d_1 + w_2\ d_2 + ... + w_k\ d_k$$

where w_i, the weight of the i'th study, is given by,

$$w_i = n_i / (n_1 + n_2 + ... + n_k)$$

The total variance of d_c can be obtained from,

$$var(d_c) = w_1^2\ var(d_1) + w_2^2\ var(d_2) + ... + w_k^2\ var(d_k)$$

For study units 1 and 2, which show no AC, these calculations calculations give $d_c = 0.078$ with a standard deviation of 0.12. For study units 3 though 6 $d_c = -0.78$ (sd = 0.15).

As a further confirmation of the variance of d_c a Monte Carlo analysis of the four significant AC study units was performed. In each Monte Carlo run the actual dates and times of the trials in each the study units were replaced with random dates and times from the period 1/1/1975 to 1/1/1985. The actual AC *z*-scores from each study unit were then used to compute the study unit's *rho* and *d* and finally the d_c value for the set of 4 study units was computed, this computation being identical to that employed for the actual data. The process was repeated 2000 times and the resulting distribution of d_c values had a mean of 0.003 with a standard deviation of 0.156, confirming the above calculation. Based on this Monte Carlo analysis, the actual d_c value obtained from study units 3,4,5 & 6 differs from its chance expectation value by a *z*-score of 5.03 ($p = 2.5 \times 10^{-7}$).

The epoch analysis of figure 1 was recalculated in terms of Cohen's d effect size and is shown in figure 3 below.

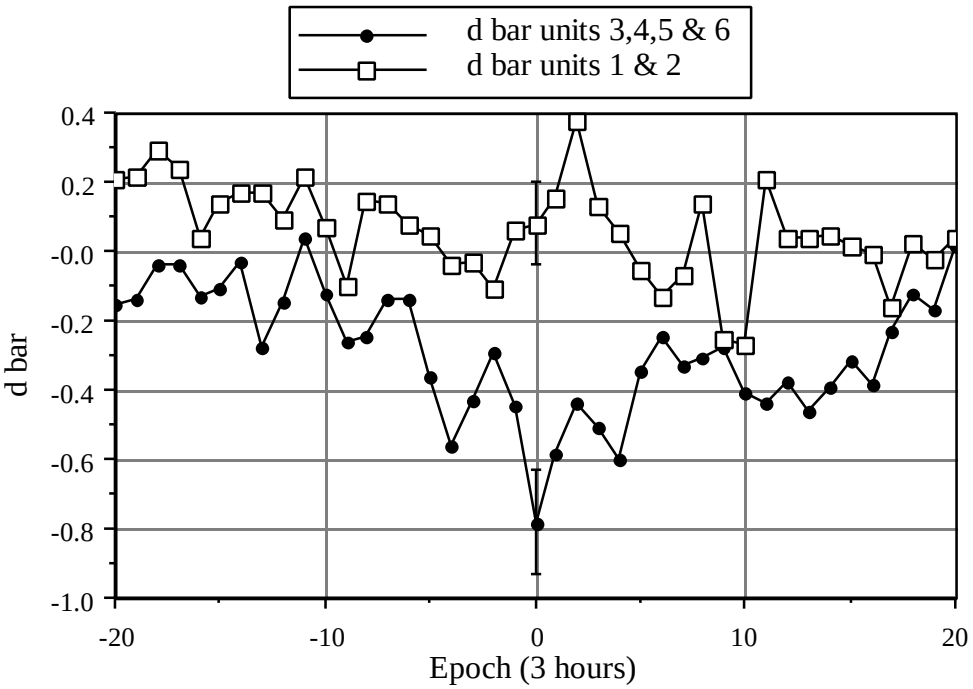

Figure 3. *Plot of Cohen's d effect size for 4 study units exhibiting significant AC and 2 study units without AC (error bars of ±1 standard deviation).*

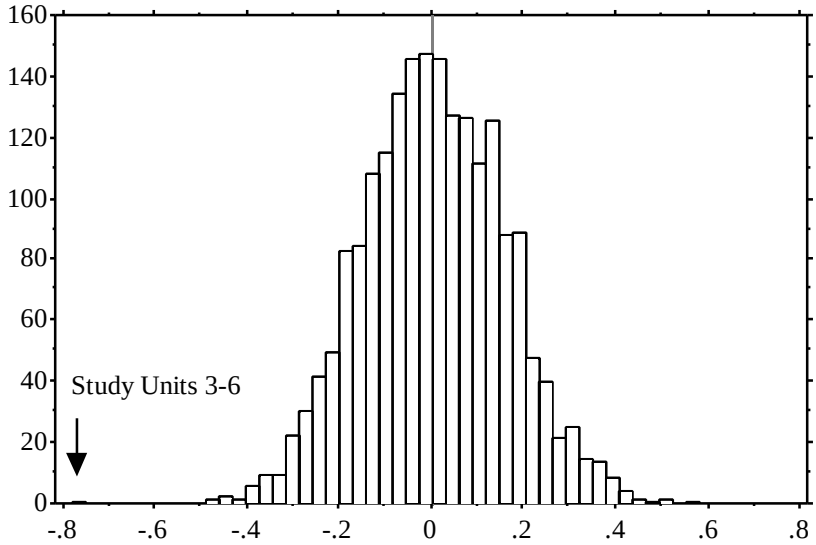

Figure 4. *Histogram of of d_C values from a Monte Carlo analysis of the data from study units 3, 4, 5 and 6.*

2. As mentioned earlier there appears to be a relationship between AC effect size and AC - GMF effect size in the data analyzed here. Figure 5 below shows a plot of GMF to AC correlation effect size versus AC effect size. As can be seen there is insufficient data in the six studies discussed here to arrive at a definite conclusion regarding this.

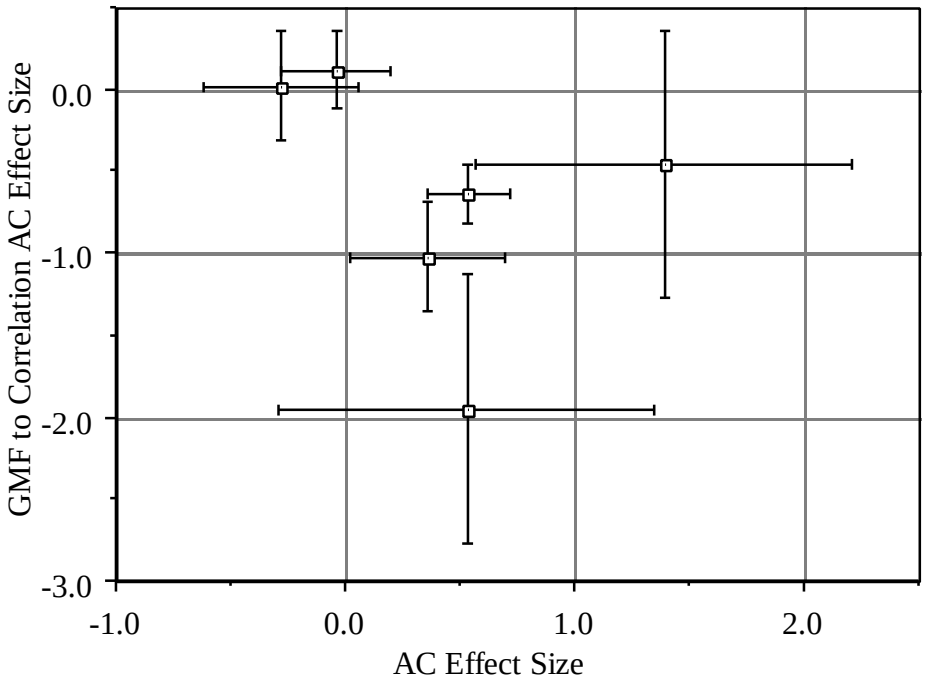

Figure 5. *Plot of Cohen's d effect size for GMF to AC correlation versus Cohen's d effect size for AC for study units 1 though 6 (error bars ± 1 standard deviation).*