Anomalous Cognition Effect Size: Dependence on Sidereal Time and Solar Wind Parameters

by

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Abstract

In a database of 2,879 free-response anomalous cognition (AC) trials the Spearman's *r* correlation between the *ap* geomagnetic index and AC effect size was -0.029 ($p = 0.06$). An increased correlation was found for trials that occurred at 13 hours Local Sidereal Time (LST). The correlation observed for trials which occurred between 11.2 h and 14.8 h LST was -0.192 ($N = 256$, $p = 0.002$) while the correlation was effectively zero ($r = -0.01$, $N = 2,623$, ns) for trials at other times. The maximum magnitude correlation of -0.33 ($N = 134$, $p = 0.0001$) was observed in the 12.9 ±1 h LST period. A subset of this data for which solar wind speed measurements were available showed a similar correlation configuration with a negative correlation peak near 13h LST. The power spectrum of the effect sizes showed a peak at 13.8 days period, which is close to twice the solar rotation rate, a period typical of solar wind modulations. These observations are consistent with the thesis that AC performance is modulated by a parameter which varies with solar activity.

Introduction

It has recently been reported that anomalous cognition (AC) performance in a large database of free response trials was correlated with the *ap* geomagnetic index for trials occurring near 13 h local sidereal time (LST) (Spottiswoode, 1997a). At other times of the sidereal day the correlation falls to zero. This phenomenon explains the difficulty found in replicating the correlation between *ap* and effect size in individual studies. Given that the correlation is observed over approximately 4 h of LST, or 17% of all possible trial times, it is hardly surprising that retrospective searches for the effect in experiments timed without regard for this result have yielded conflicting results.

This paper reports some preliminary results aimed at elucidating this relationship between AC effect size and the geomagnetic field. The variations in the earth's field strength at the surface, which are reported by the GMF indices, such as *ap*, *Ap* and *K*, are very small in magnitude. Small to moderate sized disturbances produce a change in strength of 50 – 200 nT in a total field strength of 50,000 nT at mid latitudes. Typical field gradients experienced in urban environments due to ferrous materials in buildings and automobiles are orders of magnitude greater than this. Thus it seems possible, even likely, that the GMF indices are acting as a proxy for another environmental parameter which is actually modulating the AC effect size. The changes in the GMF field strength observed during solar disturbances are one consequence of complex interactions that occur between the solar wind and radiation flux and the near space environment of the earth. As a first step to understanding which components of the solar influence on the earth's environment are responsible for the AC effect size modulation, this paper will examine correlations between several measures of solar activity and AC.

Since sidereal time is central to this analysis some brief definitions are in order. Right ascension, or RA, is an angular coordinate for directions in the sky, which is a close analogue of longitude. It measures the angle around the celestial equator, from a fixed starting point (the vernal equinox) to a given point on the sky. At any location and time, the local sidereal time (LST) is defined as the RA of the meridian, that is the great circle which passes through the zenith and celestial poles. Thus at the same value of LST for any observer, the same strip of sky will be directly overhead. Owing to the earth's orbital motion around the sun, the day as defined by the sun's apparent motion through the sky is approximately four minutes longer than the sidereal day, the period that elapses before the stars return to the same position. In other words, solar time and sidereal time drift steadily in phase relative to each other accumulating a difference of a day during the course of a year. The AC trials studied here occurred at locations in North America and Europe, mostly during office hours and at all times of the year during the last 20 years. As such they covered the whole range of LST values approximately uniformly.

Method

Data Sets

The AC data consisted of 51 free-response studies, comprising 2,879 trials, which were elicited in response to requests for formal free-response experiments (i.e. excluding exploratory trials) where trial time, date, location and score data were available. This information was collected in two stages. The first part was acquired in 1992 in an unsuccessful attempt to find a correlation to geomagnetic indices in a large assemblage of relatively high effect size AC data. This data was later used to discover an apparent increase in mean effect size in a range of LST (Spottiswoode, 1997b). Subsequent to this laboratories were asked to provide any further data they might possess, which met the same criteria, in order to build a second data-set to test the hypothesis of an LST dependence of effect size; this second batch of data replicated the effect size dependency. Following this, these two databases were combined together and later examined for correlation to the GMF *ap* index. Thus all of the data analyzed here were collected before the notion of examining the correlation to *ap*, with LST as a filtering variable, arose. Details of the studies used are given in Table 1.

The data falls into two broad groups of protocols. The first includes most of the ganzfeld work done since the 1980’s, comprising the complete data from The Psychophysical Research Laboratories, and partial data from The Institute for Parapsychology, the Amsterdam Psychology Department, the Utrecht Institute for Parapsychology and the Koestler Chair at Edinburgh University. The other major grouping consists of remote viewing trials and consists of the work of the Princeton Engineering Anomalies Research, a partial set of data from SRI International and Science Applications International Corporation, experiments by M. S. Schlitz and remote viewing experiments by the author. An exception to this division by protocol is Carpenter’s work, which was obtained in a psychotherapeutic setting. The PEAR remote viewing experiments have been subjected to some methodological criticism (Hansen *et al*., 1992; Dobyns, Y., 1992) but they are included here since the putative AC effect size observed is comparable to that seen in other laboratories using a similar protocol. The effect size increase for a range of LST was also seen in the PEAR data alone (Spottiswoode, 1997b) suggesting that the supposed artifact in this data was not in fact operative, since the LST dependency closely matches that seen in other studies free of the possible artifact.

Table 1. Studies Analyzed.

STUDY	Start Year	End Year	*N*	Effect Size	*Z*	*P*
PEAR	76	84	330	0.33	6.05	7.1×10^{-10}
Schlitz & Gruber	79	79	10	0.56	1.76	0.04
Schlitz & Haight	80	80	10	0.15	0.46	0.3
Amsterdam ganzfeld 1982	82	82	32	0.14	0.79	0.2
PRL Series 1	82	83	22	0.39	1.85	0.03
SJPS precognitive remote viewing	83	83	19	0.66	2.89	0.002
PRL Series 2	83	84	9	0.0078	0.023	0.5
PRL Series 3	83	89	34	0.28	1.65	0.05
PRL Series 101	83	84	50	-0.02	-0.14	0.6
PRL Series 301	83	85	50	0.12	0.88	0.2
SJPS analytic scored ARV	84	84	40	0.080	0.51	0.3
PRL Series 102	84	86	50	0.16	1.16	0.1
Carpenter	86	90	90	0.077	0.73	0.23
IfP Manual ganzfeld Series 003	86	86	31	-0.28	-1.54	0.9
IfP Manual ganzfeld Series 101	86	87	40	0.057	0.36	0.4
PRL Series 103	86	87	50	0.14	0.99	0.2
PRL Series 201	86	86	7	0.26	0.69	0.2
IfP Manual ganzfeld Series 987	87	88	48	0.0069	0.048	0.5
SRI Tachistoscopic feedback study	87	87	160	0.2	2.53	0.006
SRI Precognitive vs. Real-time study	87	87	81	-0.068	-0.61	0.7
SRI Hypnosis study	87	88	44	-0.070	-0.46	0.7
SRI Facsimile feedback study	87	90	40	0.41	2.57	0.005
IfP Manual ganzfeld Series 201	87	87	10	-0.48	-1.51	0.9
IfP Manual ganzfeld Series 400	87	92	38	-0.018	-0.11	0.5
PRL Series 104	87	89	47	0.43	2.91	0.002
PRL Series 105	87	89	6	1.08	2.64	0.004
PRL Series 302	87	89	25	0.71	3.55	0.0002
IfP Manual ganzfeld Series 401	88	88	12	0.38	1.31	0.09
IfP Manual ganzfeld Series 004	89	89	37	0.12	0.74	0.2
IfP Manual ganzfeld Series 202	89	89	20	-0.088	-0.39	0.6
IfP Manual ganzfeld Series 989	89	92	17	0.47	1.96	0.03
Edinburgh Pilot	90	90	69	-0.050	-0.41	0.7
IfP Manual ganzfeld Series 203	90	91	46	0.075	0.51	0.3
IfP Manual ganzfeld Series 301	90	91	20	0.018	0.081	0.5
IfP Manual ganzfeld Series 302	90	91	26	0.15	0.76	0.2
Edinburgh Train	91	91	174	0.067	0.88	0.2
SJPS magnetic field study	91	91	101	0	0.0	0.5
Utrecht S1	92	92	50	0.015	0.11	0.5
Utrecht S2	92	93	50	-0.092	-0.65	0.7
IfP Auto ganzfeld Series EC1	93	95	51	0.13	0.95	0.2
IfP Auto ganzfeld Series FT1	93	94	50	-0.26	-1.84	0.9
IfP Auto ganzfeld Series GEN1	93	94	8	-0.04	-0.11	0.5
SAIC Entropy II	93	93	90	0.55	5.22	9×10^{-8}
Edinburgh Sender-No Sender	94	94	97	0.14	1.41	0.08
Amsterdam ganzfeld 1994	94	94	37	0.31	1.90	0.03

Table 2 (contd.). Studies Analyzed.

STUDY	Start Year	End Year	N	Effect Size	Z	P
IfP Auto ganzfeld Series CLAIR1	94	96	50	-0.065	-0.46	0.6
IfP Auto ganzfeld Series FT2	94	95	50	-0.065	-0.46	0.6
SJPS Lottery ARV	95	96	216	-0.0001	-0.013	0.5
Edinburgh ganzfeld (KD)	95	96	128	0.48	5.38	3.8×10^{-8}
Amsterdam ganzfeld 1995	95	95	68	0.058	0.48	0.3
Amsterdam ganzfeld 1996	96	96	39	-0.22	-1.36	0.9

1. PEAR - Princeton Engineering Anomalies Research, Dept. of Engineering, Princeton University; IfP - Institute for Parapsychology, formerly Foundation for Research on the Nature of Man; PRL - Psychophysical Research Laboratories; SRI - SRI International; SJPS – James Spottiswoode; Utrecht - Parapsychological Institute, Utrecht; Edinburgh - Koestler Chair of Parapsychology, University of Edinburgh; Amsterdam - Dept. of Psychology, University of Amsterdam.
2. Published study *z*-scores may differ from those shown here due to alternative methods of calculating overall *Z*.

Analysis

The anomalous cognition data were delivered with a time for each trial and a score. The trial timings were known to be the start time of the mentation period for much of the remote viewing protocol data. In the case of the ganzfeld data, much of it was taken using a computer-automated protocol in which subjects were played a 15-minute relaxation tape after the start time of the trial to prepare them for the mentation period. In studies using this protocol, the given trial times were adjusted forward by 0.25 hour. Since the exact time of the mentation period has not been a measurement of particular significance in parapsychology, it is likely that some errors exist in this data. In the cases of the PRL and IfP data contributing experimenters have checked times against the original paper logs to guard against timing errors in computer clocks. Each trial's time was corrected for daylight savings time, where appropriate, and converted to Coordinated Universal Time (UTC). Geographical coordinates for the trials were obtained from the gazetteer of the Rand McNally International Atlas and these data, with the UTC timings, were used to compute the local sidereal time of each trial.

Trial scores were presented in one of three forms. In the case of some of the remote viewing data, for instance that from PEAR, an analytic scoring method had been used and *z*-scores for each trial had been calculated by comparing the trial's score with a near-normal distribution of mismatch scores. Such scores were used without further processing. In some ganzfeld experiments, a trial *z*-score had been calculated from continuous valued ratings given by the subject as an estimate of similarity between the mentation and the target and three decoys. In these cases, the *z*-score to the trial target was calculated from the mean and standard deviation of the ratings. The third category of score data originated from experiments where only ranks to the targets were available and they were converted by the following formula to a trial effect size:

$$es = \frac{r_{MCE} - r_{OBS}}{\sqrt{\left(N^2 - 1\right)/12}}$$

where r_{MCE} is the mean chance expectation rank, r_{OBS} is the observed rank and N is the number of targets used in the ranking procedure. Each of these three methods of scoring produce values which have a variance of unity and mean of zero under the null hypothesis. It is therefore appropriate to combine them as a per-trial *z*-score in an analysis of correlations to independent variables.

Geomagnetic index data for the *ap* index were obtained from the National Geophysical Data Center as the "Lenhart" data files. The *ap* index is reported for 3 hour intervals of UTC and the correlation coefficients reported here were calculated between the *ap* index for the 3 hour interval of UTC within which the mentation, or trial, start time fell and AC effect size. In all correlations to *ap* the conservative, rank order based, Spearman's *r* correlation function was used, rather than Pearson's *r*, to allow for the statistical properties of the GMF indices (Spottiswoode, 1993). The solar wind speed data were obtained from the National Space Science Data Center's OMNI database (Mathew, J. & Towheed, S, 1997).

The distribution of correlation in LST space was examined by calculating the correlation between effect size and *ap* in 2 hour wide windows of LST. This calculation was repeated for windows spaced 0.1 h apart for all values of LST from 0h to 24 h. To ensure that windows with their centers in the 0 to 1 h and 23 to 24 h time intervals had a complete set of trials, the LST and effect size data were padded with two copies of itself, with the sidereal times advanced and retarded by 24 hours. Thus a correlation, which was calculated for a 2-hour window centered at 23.5 h, for instance, incorporated times from 22.5 h to 0.5 h. The window width of 2 hours was chosen as a compromise between the greater time resolution afforded by a narrower window, and the increased noise resulting from the reduction of the number of data points. In all plots of correlations, the error bars show the estimated standard deviation of the correlation coefficients (Hedges & Olkin, 1985) calculated as:

$$s = \sqrt{\frac{\left(1 - r^2\right)^2}{n}}$$

Results

GMF Index *ap*

The complete database exhibits a mean effect size of 0.140 and resulting Stouffer's Z of 7.503 ($p = 3.1 \times 10^{-14}$) providing evidence that anomalous information transmission was observed. Figure 1 shows the correlation of the *ap* geomagnetic index to AC effect size plotted against the window center time. The overall correlation of the data ($r = -0.029$, $N = 2{,}879$, $p = 0.06$, 1-tailed) is shown dashed.

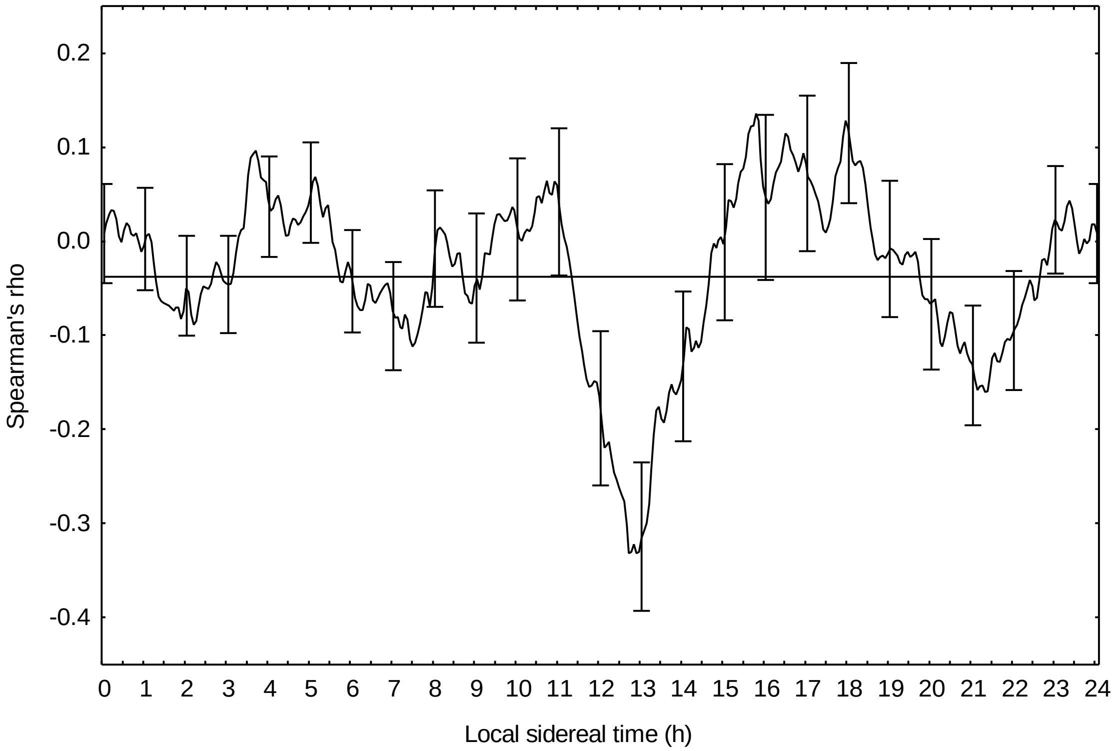

Figure 1. Correlation between *ap* and effect size versus LST.

The correlation between AC and *ap* geomagnetic index turns out to be strongly dependent on the region of sidereal time considered and there exists substantial correlation near the 13 h point where the maximum effect size was found. The maximum magnitude correlation of -0.33 (N = 134, p = 0.0001) occurs at 12.9 h, in approximate agreement with the maximum of effect size for this data at 13.3 h. Elsewhere in LST space there is little correlation. A Monte Carlo test was used to estimate the probability of seeing a correlation of this magnitude or greater at any value of LST. In each Monte Carlo run, the AC trial scores were randomly permuted. While keeping the relationship between trial times and observed *ap* values constant, the data were reprocessed in the same way as was the actual data to produce Figure 1. That is, a 2-hour wide window was run across the data in 0.1-hour increments and the Spearman correlation found for each of the 241 windows. In 32,000 such runs, 20 had a window at some value of LST with a negative correlation greater than the observed value giving an estimate of the probability of observing such a correlation under the null hypothesis of 0.0006.

Taking as the correlation region the period between 11.2 h and 14.8 h LST, where the correlation shown in Figure 1 crosses zero, the correlation in this “in-band” was -0.192, N = 256, p = 0.002, whereas the correlation outside was -0.010 (N = 2,623, ns). This negative correlation with *ap* in the in-band region of LST space was found to homogeneously replicate across the 21 studies for which there were 5 or more data points in the in-band period (Spottiswoode, 1997). Comparing the protocols in this sample, for ganzfeld data the overall correlation across all trials was -0.023, (N = 1609, ns), whereas in the in-band r = -0.18, (N = 145, p = 0.03). In the case of remote viewing, the correlation of all the data was -0.032 (*N* = 1,254, ns) while the in-band correlation was -0.21 (*N* = 113, *p* = 0.03). The correlation effect at 12.9 h therefore also replicates across these protocols. These results demonstrate that the correlation is present in different studies and protocols.

Solar Wind Speed

The solar wind consists of a continuous outflow of high temperature matter from the sun – it is essentially the distended region of the solar corona. At the earth's distance from the sun it consists of a fully-ionized plasma, consisting primarily of protons, double ionized helium and electrons at a temperature of around 10^5K traveling at approximately 450 km s^{-1}. Although the detailed physics of the interaction of this wind with the earth's magnetosphere is complex, the principal interaction can be easily understood qualitatively. The solar wind plasma is a near perfect conductor and as such cannot cross the field lines of the GMF. The pressure of the wind therefore distorts the earth's field and a dynamic pressure balance is maintained between the two. During times of increased solar activity the solar wind speed can increase further compressing the earth's field and leading to GMF strength changes at the earth's surface, which are reflected in the GMF indices, such as *ap*. It is therefore of interest to see whether the correlation of *ap* to AC effect size is reflected in a similar correlation to plasma speed. One would hypothesize that increased plasma speed would be associated with reduced AC effect size and that this would hold only in the region of 13h LST, where the *ap* correlation is observed.

Plasma speed data were obtained from the NSSDC database as an average speed for each UTC day of the 20-year period over the AC data were collected. Using daily averages increased the number of usable points since there are frequent gaps in the hourly data when no measurement is available. Much of the data comprises averaged measurements from more than one spacecraft. Of the 2,879 AC trials plasma velocity values for 1,721 were retrievable, a subset which still covers the whole period of the AC data from 1976 to 1996. The solar mean wind speed for the days of the AC trials was 452.5 ± 111.3 Km s^{-1}. As was hypothesized a negative correlation was observed between plasma speed and *ap* index in the region near 13 h LST (*r* = -0.27, *N* = 81, *p* = 0.01). As with the *ap* index, there is little evidence of correlation between plasma speed and AC effect size in the data overall (*r* = 0.03, *df* = 1,719, *p* = 0.2). The correlation between plasma speed and AC effect size, as a function of LST, is shown in Figure 2. As in Figure 1, correlations were calculated for 2 h wide windows using Pearson's *r* correlation coefficient, since the plasma speed data are a continuous measure, unlike the granular *ap*. The maximum correlation, *r* = -0.23 (*df* = 88, *p* = 0.02) occurs at LST = 12.6h in close agreement with the maximum *ap* correlation at 12.9h and the effect size maximum at 13.3h. Taking the correlation peak to be region where the correlation first goes negative in Figure 2, we find that for LST values between 9.8h and 14.2 *r* = 0.16 (*df* = 222, *p* = 0.02). Outside this period, in the remainder of LST space, AC performance is weakly positively correlated with solar wind speed (*r* = 0.06, *df* = 1532, *p* = 0.02). There is also a positive correlation at 15.6h where *r* = 0.27 (*df* = 95, *p* = 0.01).

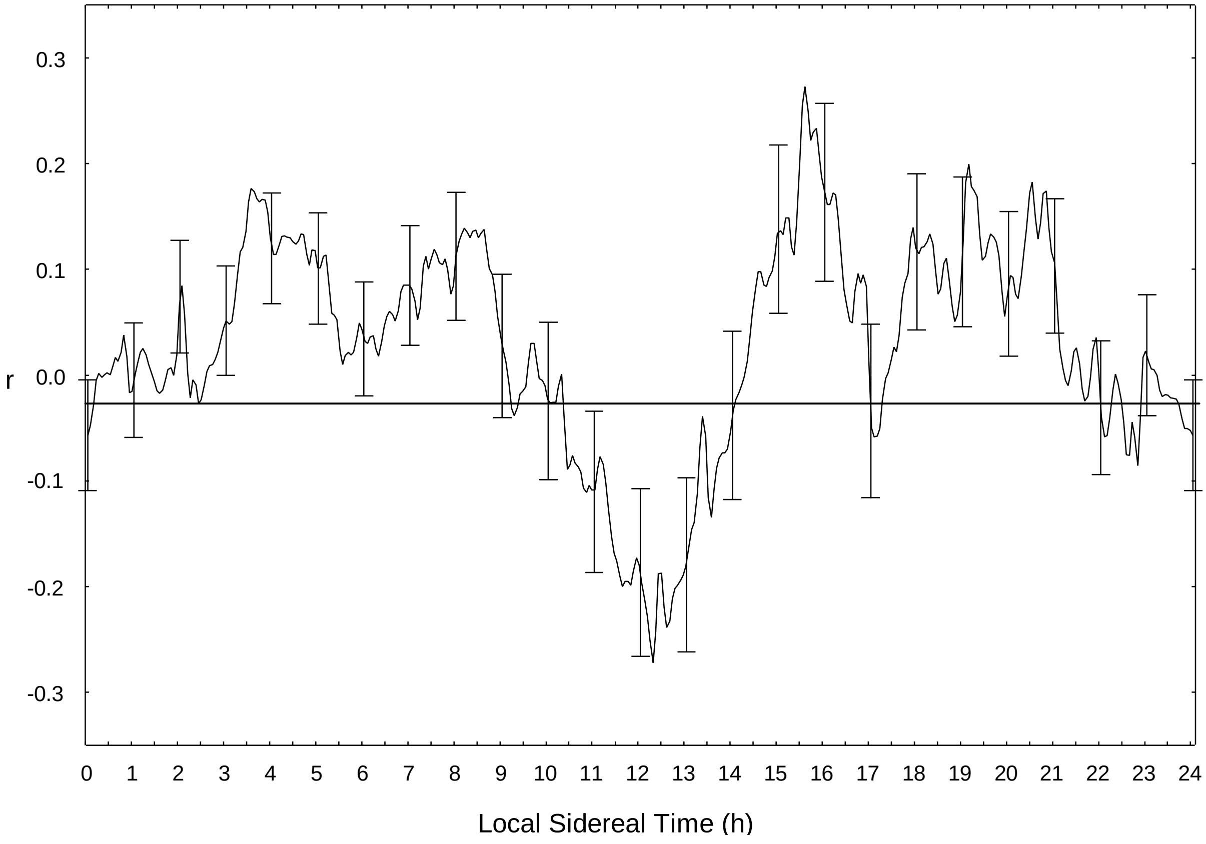

Figure 2. Correlation between plasma speed and effect size versus LST.

Effect size power spectrum

The properties of the solar wind, such as its velocity, temperature and the interplanetary magnetic field, vary over time and are strongly influenced by the presence of active regions on the sun. Solar wind parameters measured in near-earth space therefore typically have a modulation at the solar rotation rate of 27 days and its harmonics. Given the correlations between anomalous cognition effect size and geomagnetic field variations and solar wind speed it might be expected that the effect size itself might show similar modulations. This possibility was suggested by P. A. Sturrock (personal communication, December 1996) and, using a subset of the AC data examined in this paper, he found a peak in the power spectrum at approximately twice the synodic solar rotation rate.

The power spectrum of the effect sizes for the 2,879 trials discussed here was calculated by the method of Lomb and Scargle (Press *et al*., 1992, and references therein), which is appropriate when the data points are not at equally spaced time intervals. A strong peak in the spectrum was found to be at 13.84 days period, which is approximately half the synodic solar rotation rate of 26.9 days. The expected period for a quantity which is influenced by the solar wind is somewhat uncertain. The instantaneous period observed at the earth of, say, the interplanetary magnetic field, depends on the configuration of the coronal magnetic field during the period considered. It is therefore not clear what significance should be attached to discrepancy between the period observed in the AC data power spectrum and typical values given for the solar rotation rate.

To obtain an estimate of the probability of finding this power peak in the effect size data, a Monte-Carlo method was used. In each Monte-Carlo run the 2,879 effect sizes were randomly re-ordered with respect to their associated dates and times and the power spectrum calculated. The region of the spectrum covering the periods 13.5 ± 0.5 days was examined for a power peak equal to or greater than that of the 13.84 day peak seen in the real data. In 1000 such runs 27 contained such a peak. Therefore the probability of observing a power peak of the magnitude seen in the AC data at any period in the 13.5 ± 0.5 days range by chance is approximately 0.03.

Discussion

An association between geomagnetic field fluctuations and AC effect size has been observed for trials which occur near 13h LST. This association has also been seen in one parameter, the solar wind speed, which is known to affect the GMF. Finally, a possible identification of solar modulation in the effect size data itself has been found. These observations are consistent with the thesis that some component of solar activity, which correlates with solar wind and GMF variations, is modulating the amount of AC observed in laboratory experiments. It is not yet possible to determine what exactly this parameter is, or even where it is acting. One assumption is that the physical conditions at the location of the subject, or receiver, are crucial to performance. But this need not logically be so: conditions along the path through space-time followed by the AC information could also affect the propagation. Certainly if the mechanism of AC information transfer is at all analogous to that of the other senses, this should be expected. The great difficulty in the case of AC is that the location of the signal source is unknown, and therefore also the path followed by the information. The meta-analytic evidence for precognitive AC (Honorton, 1989), in which the target choice is made after the receiver has collected information, demonstrates that the signal path must include at least a section which violates the usual notion of causality. It is to be hoped that the two physical correlations described here, the modulation of effect size by LST and the correlations to solar activity, will help narrow the search for the AC mechanism.

Acknowledgements

The authors gratefully acknowledge the assistance of Dr. Richard Broughton of the Institute for parapsychology,

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