

PSYCHIATRIC WARD BEHAVIOUR AND GEOPHYSICAL PARAMETERS

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IN a previous investigation¹, we attempted to determine whether any relationship existed between a geophysical parameter and human behaviour. The findings indicated that statistically significant low to marked linear relationships exist between the more intense periods of natural geomagnetic activity, as reflected in days of principal magnetic storm, and a gross measure of psychological disturbance, as reflected in psychiatric hospital admissions.

Before the more important problem of causal relationship can be investigated, it is necessary to delineate further any geophysical parameter and to use more specific and intensive measures of human psychic disturbance. The present investigation is an initial step in this direction.

Cosmic ray activity provides a quantifiable geophysical measure which is related to geomagnetic activity. A frequent, though not invariable, association of decrease in high-energy cosmic ray intensity with accompanying magnetic storm, the so-called Forbush decrease, has been well reviewed^{2,3}. Cosmic ray activity may, in fact, provide a more statistically useful, albeit indirect, index of geomagnetic activity in view of the complexities of scaling K -indexes as compared with the relatively simple readings obtained from neutron monitors. (The K -index scale is a quasi-logarithmic measure reflecting the amplitude of the most disturbed component of the magnetic field measured every 3 h. For a complete description of the technique in scaling K -indexes see ref. 4.)

Hospital admissions to seven central New York State psychiatric hospitals and to the Psychiatric Service of a Veterans Administration General Medical and Surgical Hospital from July 1, 1957, to October 31, 1961, were correlated for 7-, 14-, 21-, 28- and 35-day periods with cosmic ray activity for the same periods of time. The reasons for selecting these periods of time for the correlations as well as more detailed description of the admission data have already been given¹. The Ottawa Observatory of the Division of Pure Physics, National

Research Council, Canada, provided cosmic ray data in the form of neutron counts for every 2 h and daily sums. For the purpose of making correlations with the admission data the daily sums were added to provide 7-, 14-, 21-, 28- and 35-day totals. Data were missing for 6 out of the 1,584 days.

Table 1 shows the product-moment correlation coefficients, r , obtained from the comparison of the 7-, 14-, 21-, 28- and 35-day periods of hospital admissions with the measures of cosmic ray activity for the corresponding periods of time. The number of pairs of comparisons available for each correlation is designated by N .

In comparison with the findings of the previous investigation¹, the coefficients obtained from correlating hospital admissions with cosmic ray activity are consistently larger than those obtained using such a measure of geomagnetic activity as number of days of principal magnetic storm. Further, whereas the total range of geomagnetic activity, as reflected in planetary (ap) or more local (ak) natural magnetic field intensity parameters, had revealed no significant relationships with psychiatric hospital admissions, the total range of cosmic ray activity does demonstrate statistically significant relationships. Although these findings are of heuristic value, they do little towards advancing or clarifying our previous speculative conception¹ that organic behaviour is significantly influenced, through the direct current control system, by external force fields. If, however, the possibility that cosmic ray activity provides indirect indexes of natural geomagnetic intensity variations is entertained, it would be reasonable to expect that significant correlations would occur between psychiatric ward behaviour and cosmic ray indexes, but, in view of the previous findings, not with total range of geomagnetic activity as conventionally measured. The direction, positive or negative, of such anticipated significant correlations would be impossible to predict in view of the complex and differential relationship between the various types of cosmic rays, solar and galactic, high-energy and low-energy, and terrestrial geomagnetic fields^{2,3}.

In the hope of clarifying some of these issues, an investigation of the relationship between the ward behaviour of selected psychiatric patients and geophysical parameters was undertaken.

Eight male psychiatric patients, ranging in age from 31 to 53 years, hospitalized on the Psychiatric Service of a General Medical and Surgical Veterans Administration Hospital, were selected for examination based on the criteria of anticipated minimal therapeutic intervention and absence of significant physical disease or disability. All were diagnosed as schizophrenic with the following sub-types: four paranoid, two undifferentiated, one catatonic, and one simple. To obtain measures of patient

Table 1. CORRELATIONS BETWEEN COSMIC RAY ACTIVITY AND PSYCHIATRIC HOSPITAL ADMISSIONS

| Admission periods | No. of r's | Range | Median r | No. of significant r's ($P < 0.05$) |
|-------------------|--|------------------|----------|---------------------------------------|
| 7-day | 5($N = 224$) 1($N = 223$) 1($N = 222$) | + 0.101 + 0.188 | + 0.168 | 6 |
| 14-day | 3($N = 112$) 5($N = 111$) 6($N = 110$) | + 0.179- + 0.271 | + 0.223 | 11 |
| 21-day | 9($N = 74$) 7($N = 73$) 5($N = 72$) | + 0.201- + 0.311 | + 0.260 | 18 |
| 28-day | 17($N = 55$) 6($N = 54$) 5($N = 53$) | + 0.263- + 0.368 | + 0.305 | 27 |
| 35-day | 5($N = 44$) 29($N = 43$) 1($N = 42$) | + 0.249- + 0.381 | + 0.331 | 32 |

behavioural change, a brief ten-item, four-point Nurse's Evaluation Scale, as developed by Gorham and Betz⁵ for use with schizophrenic patients, was used. This provided an over-all numerical score for each subject. Each patient was rated daily on this scale by the consensus opinion of the ward nurses, starting on December 5, 1962. Daily ratings were continued for each patient until some major therapeutic or administrative intervention came about, for example, institution of physical therapy, new chemotherapeutic programme, discharge, hospital transfer. It should also be pointed out that some of the patients were granted occasional pass and leave privileges. Thus, the number of days of rating for each patient differed. This phase of the investigation, however, was considered formally concluded 67 days later, on February 9, 1963.

Daily measures of geophysical parameters were obtained as follows. Measurements of the natural geomagnetic field intensity, K -indexes, as reported by the Fredericksburg Magnetic Observatory, Virginia, were obtained from the Coast and Geodetic Survey, U.S. Department of Commerce. These were then converted into more appropriate measurements, daily ak sums, as described elsewhere¹. Two sets of measurements of cosmic ray activity were obtained. The daily total neutron counts as measured at the Deep River Neutron Monitor, Ontario, were provided by Atomic Energy of Canada, Ltd. Daily cosmic ray indexes, as measured by the Climax Neutron Monitor, were obtained from the compilations of *Solar-Geophysical Data*, published by the U.S. Department of Commerce, National Bureau of Standards, Central Radio Propagation Laboratory, Boulder, Colorado.

Pearson product-moment correlation coefficients were computed between the daily measures of the geophysical parameters and each patient's behaviour rating for the same day, rating for the next day, and rating for the subsequent day. (Statistical assistance was provided in part by the Veterans Administration Midwestern Research

Support Center, Veterans Administration Hospital, Hines, Illinois.) Thus, behavioural changes were related to geophysical events occurring approximately simultaneously in time, occurring the previous 24 h, and occurring two days previously.

The measure of natural magnetic field intensity, *ak*, with but rare exception accountable for on a chance basis, provided no significant coefficients when correlated with behavioural rating. The findings for the cosmic ray indexes are presented in Table 2. Considering the correlations with Canadian cosmic ray data, it can be observed that half the subjects showed statistically significant correlations when the measures of the geophysical and behavioural parameters were obtained during the same 24-h period. When the daily behavioural measures were correlated with cosmic ray indexes for the previous 24 h, 6 of the 8 subjects showed statistically significant coefficients. The number of subjects with significant correlation coefficients increased to 7 out of 8 when the cosmic ray measures were compared with behaviour ratings for the 24-h period two days later. The coefficients obtained, using the Colorado data, demonstrated the same trend but were much attenuated, probably due to the considerable difference in geographical proximity of the recording stations to the hospital. Thus, from 3 out of 8 significant correlation coefficients for simultaneous time periods there was a change to half the subjects showing significant correlations whenever the cosmic ray indexes were obtained for time periods prior to those for the behavioural measures.

The foregoing investigation was repeated using 4 different schizophrenic patients, starting on May 28, 1963, and lasted for a maximum of 55 days. The subjects ranged in age from 25 to 53 years, with diagnostic subtypes designated as three undifferentiated and one paranoid. Correlations with *ak* revealed no significant findings. Table 3 presents the cosmic ray indexes and ward behaviour ratings. With regard to Canadian cosmic ray indexes, half the subjects showed significant correlations with behavioural ratings obtained for the same period of time or 1 day later. Three out of the four sub-

Table 2. CORRELATIONS BETWEEN COSMIC RAY INDICES AND WARD BEHAVIOUR RATING—INITIAL

| Sub- ject | <i>N</i> | Deep River same day | Deep River 1 day previously | Deep River 2 days previously | Climax same day | Climax 1 day previously | Climax 2 days previously |
|--------------|----------|------------------------------|--------------------------------------|---------------------------------------|-----------------------|-------------------------------|--------------------------------|
| <i>A</i> | 64 | -0.238 | -0.313* | -0.398* | -0.245 | -0.260* | -0.315* |
| <i>B</i> | 66 | -0.541* | -0.555* | -0.625* | -0.503* | -0.521* | -0.552* |
| <i>C</i> | 48 | +0.349* | +0.375* | +0.347* | +0.197 | +0.231 | +0.274 |
| <i>D</i> | 38 | -0.504* | -0.648* | -0.684* | -0.644* | -0.703* | -0.714* |
| <i>E</i> | 62 | -0.222 | -0.244 | -0.329* | -0.202 | -0.199 | -0.180 |
| <i>F</i> | 53 | +0.187 | +0.130 | +0.047 | +0.119 | +0.089 | +0.047 |
| <i>G</i> | 37 | -0.271 | -0.390* | -0.441* | -0.195 | -0.214 | -0.198 |
| <i>H</i> | 49 | +0.523* | +0.501* | +0.482* | +0.530* | +0.550* | +0.559* |

* Indicates statistical significance $P < 0.05$.

Table 3. CORRELATIONS BETWEEN COSMIC RAY INDICES AND WARD BEHAVIOUR RATING—REPLICATION

| Subject | <i>N</i> | Deep River same day | Deep River 1 day previously | Deep River 2 days previously | Climax same day | Climax 1 day previously | Climax 2 days previously |
|----------|----------|---------------------|-----------------------------|------------------------------|-----------------|-------------------------|--------------------------|
| <i>I</i> | 54 | +0.334* | +0.339* | +0.319* | +0.229 | +0.216 | +0.154 |
| <i>J</i> | 54 | -0.532* | -0.518* | -0.460* | -0.411* | -0.457* | -0.399* |
| <i>K</i> | 49 | -0.120 | -0.197 | -0.308* | -0.061 | -0.183 | -0.270 |
| <i>L</i> | 35 | -0.131 | -0.194 | -0.297 | -0.051 | -0.213 | -0.371* |

* Indicates statistical significance $P < 0.05$.

jects demonstrated significant correlation coefficients when the behavioural ratings were made 2 days later. Again the findings using the Colorado cosmic ray indexes resembled the findings with the Canadian data, providing a maximum number of significant correlations, two out of four, when ratings were made two days after the geophysical measure.

In general, the findings with regard to the geophysical parameters under investigation are more provocative than definitive, particularly in delineating specific hypothesized causal processes or mechanisms.

This investigation confirms the absence of a significant relationship between total range of geomagnetic activity as measured conventionally, and parameters of human psychological disturbance. Cosmic ray indexes, on the other hand, are geophysical parameters which relate significantly to both gross crude measures of human disturbance, such as psychiatric hospital admissions, and individual specific measures, as ratings of ward behaviour. A more precise statement, in view of both significantly positive and negative correlation coefficients, is unwarranted. In terms of psychiatric hospital admissions, however, cosmic rays correlate in a significant consistently positive linear fashion with coefficients of marked magnitude as high as +0.381, particularly when time periods of 28 or 35 days are used. It is especially the findings with ward behaviour ratings which make it impracticable to define more specific relationships. At the best it can be pointed out that statistically significant relationships of striking magnitude between cosmic ray indexes and ward behaviour can be observed in the majority of schizophrenic patients, particularly when ratings are made 1-2 days after the geophysical event. It is interesting to note that Winckler³, in his description of the characteristics of low-energy cosmic ray flares, indicates that such flares produce strong geomagnetic disturbances 1-2 days later.

It is apparent that cosmic ray indexes provide more significant parameters of geophysical events related to human behaviour measures than do the more typical measures of geomagnetic activity, as *K*-index or *ak*. This is not to say, however, that in the aetiological speculations cosmic ray activity may necessarily be the significant geophysical parameter. As with magnetic field intensity,

it must be remembered that it is possible that the most meaningful geophysical parameter may not be cosmic ray activity *per se*, but rather some other geophysical variable closely associated with it.

It is always tempting to try to comprehend empirical findings within some conceptual scheme. Unfortunately, that framework in which the present findings could fit most comfortably is very general and has almost assumed the character of a platitude. Thus, there are limiting ranges for environment parameters, as, for example, temperature and atmospheric oxygen content, within which organic life can survive, adapt, and function optimally. The indication is that geophysical variables should be included within this set of highly significant environmental parameters. Further specification of limits, of predicted direction of effect on the organism, and the role of other variables modifying both limits and direction remains to be investigated. If speculations are made from the point of view of cause, the replicable findings of relative absence of chance-level relationships between cosmic ray indexes and ward behaviour ratings point to a demonstrable effect of a geophysical parameter on human behaviour. The nature of this effect remains at present unresolved. In this respect, Brown's work with the response of the common planarian worm to weak γ -radiation⁶, to weak electrostatic gradients⁷, and to weak horizontal magnetic fields⁸ may be pertinent. The fact that the organism responded to the application of these environmental stimuli was clearly established, but the magnitude and the direction of response—turning away from, or toward, the source of stimulation—depended on such variables as orientation in the Earth's geographic field, season, lunar phase, and time of day.

In terms of process or mechanism which would provide predictable effects of geophysical parameters on organic behaviour, it is difficult to consider the present findings as adding further definition. In our previous report¹ it was suggested that the relationship of geomagnetic parameters to a gross index of human psychic disturbance could be consonant with the conception that organic behaviour was significantly influenced, through the direct-current control system, by external fields of force. Only if the cosmic ray indexes, neutron counts, used in the present investigation, are considered as indirect measures of some field of force, either one not as yet considered or a geomagnetic parameter, do the present findings become consistent with the previous speculation, for neutrons *per se* could have little significant effect on the direct current electrical system. In view of the growing body of empirical findings and occasional experimental investigations in the area of the biological effects of magnetic fields⁹⁻¹¹, it would seem that the most fruitful interpretation would lie in the possibility that the cosmic ray

indexes provide a measure of some geomagnetic parameter.

Further investigation must now lie in the direction of longitudinal individual examination as well as in the experimental production and control of geophysical variables to determine relationship to human behaviour and psychological processes.

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