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Hans W. Wendt
Macalester College

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HANS W. WENDT*

ABSTRACT – Recent Russian studies reported associations between adaptation syndromes and (solar activity-related) interplanetary magnetic field (IMF) sector polarity. Certain ambiguities in the original work suggested some reanalyses, based on the graphs and data made available. Syndrome status exhibited a biphasic (semi annual) trend. It also correlated with specific geomagnetic changes during magnetic storms and possibly after sudden impulses. Moreover, lag effects and higher order interactions were noted among all parameters investigated. The restudy tends to support some of the original findings but also suggests new conclusions regarding potential relationships between geophysical/solar and psychophysiological processes.

From time to time it has been suggested that geophysical factors associated with solar events - flares, storms, etc. - influence physiological and even behavioral processes. Actual data on humans have not been impressive, and reviewers urge great caution in interpreting any such relationships (Halberg, e.g., 1969; Pokorny and Mefferd, 1966; Tromp, 1974).

Some previous limitations of such research have since been overcome by routine recording of parameters through surface as well as satellite-borne sensors. Perhaps more important, theoretical reorientations such as "adaptation models" of neurophysiological functioning may focus on the stress total resulting from either the transient disappearance of a background factor, or a change in its periodic characteristics (Hensel, Hildebrandt, 1967). Thus the organism's overall adaptation to a changing ecology as such would become relevant rather than something like a one to one ("magical") relationship between some external, e.g. solar "cause" and a behavioral or biological "effect". Certain background factors which are usually present also may serve to time physiological functions, as observed for animals and plants by Brown (1976) and including geomagnetic variables.

Logically similar applications have been appearing in recent studies of the U.S.S.R. Academy of Sciences, where geophysical measures were systematically related to neurophysiological ones (Nikolaev et al., 1976; Cernuch et al., 1977). The ecology of interest there included oscillations of the geomagnetic field which are apparently due to the interaction of charged particles and fields of solar origin with the earth's magnetosphere (Wilcox, 1968); the usual amplitude is in the gamma range. Periods around one minute (categories Pc 2-4) are especially interesting as part of the nearly continuous background activity for biological systems, whether or not these can detect their presence or absence for cognitive processing. However, if we assume that human life is somehow adapted to the presence of these fast ultradian rhythms, it is a small step to argue (as some have done) that they may have become integrated as components which acquired specific roles along with other features of the ecology. All of this is granted that at present we know little or nothing about the modes by which such signals could enter into neurotransmitter sequences, for example, or could affect hypothalamic function.

Current findings suggest that the oscillation background is closely related to the condition of the interplanetary medium between sun and earth. A magnetic storm may greatly enhance all such activity; at other times a similar storm - as well as solar "sudden impulses" or commencements - may be accompanied by its nearly total cessation anywhere on earth. The Russian researchers in particular have been paying much attention to the interplanetary magnetic field (IMF) which originates at the solar surface and is sealed in, as it were, into the plasma stream. Since status changes at the sun are transmitted by this solar wind (with velocities around 3×10^2 km/sec) as well as at the speed of light, two components at least are involved with respect to responses by an organism on earth: one adjustment (if any are called for) would have a minimum lag of about eight minutes, the other from 2.5 to 6 days. It will be seen that this differential may in fact assist understanding of some actual suggestive relationships.

Assuming that the 5 to 150 sec (Pc 2-4) periodicity in particular is a regular and perhaps necessary component of the background, the Moscow researchers concentrated on the adaptation processes occurring whenever the activity decreased or ceased by observatory criteria or other such means. They focus especially on the "adaptation illnesses," syndromes ascribed to malfunction of hypothalamic structures. It seemed plausible that healthy individuals would not be unduly affected by cessation of the pulses but patients might show excitation, cardiovascular or other crises. Because of the intimate linkage between solar flares, the interplanetary magnetic field carried by solar wind, and the geomagnetic status, they examined relationships between such adaptation crises and the polarity of the IMF sectors which rotate, spiral fashion, with the sun. Nikolaev *et al.* (1976) make the following statements(Here and in later quotations their translation has required occasional adjustment, but generally is presented verbatim): (There is a) ". . .hypothesis. . . about a possible negative factor affecting organisms with disturbed adaptation systems . . . In crossing IMF sector boundaries by the earth . . . some unfavorable conditions are created . . . for patients with vegetative-vascular dystonia; ischemic heart disease; stenocardy . . . One may assume that in some cases an ill organism needs nearly constant . . . quasi-sinusoidal oscillations of electromagnetic field with a certain frequency from outer source . . . Absence of such oscillations for some time may have a fatal (sic) influence upon the . . . organism. The role of such outer factors may be played by the geomagnetic field pulsations disappearing . . . all over the earth simultaneously . . . and nearly always during the earth's passage through the boundaries between IMF sectors . . ." These authors recommend as others have done for diagnostic groups involving different neurological criteria (Cernuch et al., 1977), that the results of such work, through monitoring IMF parameters, etc., can and should be "applied to clinical practice even now" by concrete prophylactic measures.

*HANS W. WENDT is a professor of psychology at Macalester College, St. Paul, Minnesota, and a visiting researcher at the University of Minnesota Chronobiology Laboratories.

One of the research groups active in the field (Nikolaev et al., 1976) studied a total of 75 adult male and female in-patients from March 22, 1975, to January 12, 1976. The daily complement of patients varied with new admissions and discharges. Recalculation of tables shows schizophrenic and neurotic overall diagnosis most prominent (36 and 21 percent), along with anxiety related presenting symptoms (43 percent). Patients underwent so-called diet therapy as designed by the senior authors, and staff kept logs of relevant symptom severity (S) for each patient, apparently summarizing at the end of each day on a 6-point scale. Data were subsequently correlated with various geophysical and solar information furnished by the U.S. and U.S.S.R. circumpolar stations (Thule and Vostok) as well as the global geomagnetic integrations performed by the Goettingen observatories.

The procedure presumably eliminated the risk of influencing patient assessment by a knowledge of the geophysical status for that day. The technique cannot eliminate some other problems, although the tenor of reports suggests that the investigators do not consider them relevant. There is the possibility (1) that staff may respond to their own changing sensitivity to patient symptoms (where not clearly objectifiable, that is) rather than actual status. Also, (2) interaction among patients on the wards may cumulate to some overall rating that is effectively due to only a few of them. Factual distortions on those accounts may or may not be negligible, but they would in themselves be interesting evidence of some sort of correlation. The available technical report concentrates on several main findings as follows:

The most important observation is an intensification of snydromes (S) during the first third of each positive IMF polarity segment ($P < 0.001$) as well as near the end of the sector ($P < 0.02$). During the negative periods symptom aggravation is also seen initially ($P < 0.01$). Some of the statistics given are apparently based on t-tests between segment means. In respect to polarity as such, positive days are accompanied by more intensification in general. The stated overall difference (31 vs. 18 percent) may be recalculated as nearly significant with Chi^2 3.8, $P < 0.06$; however, this is too conservative in light of other more sensitive comparisons using their data and which confirm the authors' findings at higher levels of reliability.

The report also notes that results are substantiated by the admissions records of another clinic where "the number of hospitalized patients visibly increased two to three days after the change of IMF polarity.." These findings taken as a whole might eventually relate to some other "interdisciplinary" frameworks. For example, it has been hypothesized - admittedly a very indirect link to the above - that negative ions stimulate, while small positive ions block biochemical processes such as monoamine oxidase action. Evidence of this is reviewed by Krueger and Reed (1976).

While alluding to other potential relationships with geophysical status, particularly the geomagnetic index Ap, the authors' discussion is inconclusive, and quantification is rarely attempted. Thus in commenting on their figure No. 1, they state, "clearly seen is the 27-day periodicity of outer factor (Ap) and the patients' reaction. . ". For the vicinity of boundary passages they find that ". . . a distinct relationship of S with Ap has not been observed . . ", and ". . . some (very slight) resemblance . . . might be noticed . . ", respectively, depending on direction of IMF polarity change. To readers used to a different descriptive format, and due to translation problems, the meaning is not always transparent. The evident importance of any outcome even for therapy, however, suggested certain additional analysis. Admittedly this presented problems for a reviewer unfamiliar with particulars of the original methodology and lacking expertise in geophysics. While some counsel was obtained in those regards, it should be clear that some of our new interpretations may be confounded by errors not ascribable to the original researchers.

Fortunately, the authors presented several graphs which can be retransformed into original data to some extent. Thus the daily coordinates of all curves furnished by Nikolaev *et al.* (1976) were transcribed into numerical format. The reformating may involve reading errors up to five percent of maximum scale. This uncertainty would if anything lead to less significant or more conservative estimates due to the additional random variance.

Several aspects of the problems noted here are addressed in what follows, but without implying an order of importance.

Solar month phenomenology

Tests involved a spectral analysis (based on the figures from Nikolaev *et al*) 1) of the syndrome distribution over the ten-month reporting period, probably replicating the original technique. Within the limits of resolution possible, a 27-28 day component was clearly seen. This would confirm that, indeed, solar rotation or its corollaries appear to be involved in the neuropsychiatric 'dependent variable' (?) cluster. There are various complications to be considered, however, of which more below. Also, such a finding says nothing about the exact mediation, a problem recurring throughout the reanalysis summaries.

Syndrome aggravation and geomagnetic activity surrounding sector boundary passage

This analysis centers on figure 3 of the original paper, where patterns extending from six days before through six days after the boundary passage can be reconverted into numbers. Both direct and lag correlation methods were employed in order to translate the authors' assessment (which is largely negative) into quantitative format.

Since the original researchers had already found a relationship between polarity as such and the syndrome measure, any first order correlations computed between Ap and S might conceivably be spurious on those grounds. Interesting to be sure, but clearly redirecting one's concerns in that case. There is no fully satisfactory expression for the required partial correlation here. However, if we consider the four-fold-point coefficient r_p (which is compatible with r) as an acceptable substitute for a biserial, we have $r_p = 0.67$ for the correlation between polarity and symptoms, as well as 0.67 for the correlation between polarity and Ap. Now using the conventional formulation for partials, and the more interesting case of polarity changes from positive to negative only, the original correlation is weakened as expected but does not vanish: The relationship between geomagnetic index Ap and syndrome S, after the polarity interaction is partialled out, is $r = 0.39$ for zero lag, and $r = 0.75$ ($p < 0.01$) for the 24-hour lag assumption. These values compare with the first order r's of 0.66 and 0.86, respectively. The overall result does suggest, (1) at least in the boundary region there is a genuine or "residual" association between factors related to the geomagnetic measure and the syndrome; and (2) the very existence of such a relationship depends on the direction of the sector passage. Table 1 summarizes various outcomes.

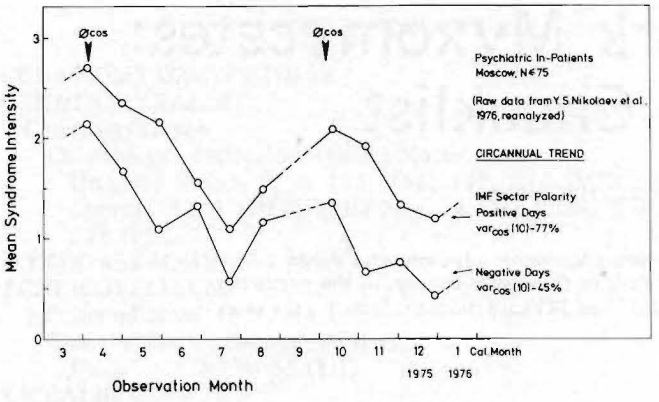

Figure 1 — Circannual trend of syndrome, by IMF sector polarity.

associations found for either magnetic storms or the period as a whole. In all four instances the impulses were followed by conspicuous syndrome intensification an average of 2.3±0.96 days after the event. A second, minor maximum centered on 7.0±0.82 days. On the other hand, again in all four instances, the buildup of Ap showed three conspicuous maxima, with the middle one by far the largest in amplitude and occurring 6.0±0.82 days after the impulse. Two minor maxima fell on 2.0±0.0 and 9.8±1.5 days. The internal consistency of both patterns, together with the absence of a positive concurrent correlation between them (unlagged r =-0.45) might suggest that the geomagnetic changes after impulses are not mediating the neuropsychiatric syndrome. This is entirely possible, but there also is a lag correlation between the patterns. That is, Ap and S correlate at r max = 0.65 if a five day lag is assumed between the geomagnetic change on the one hand and the organismic variables on the other; indeed five days is approximately the time it takes the plasma to arrive in earth vicinity. The problem with this reasoning is not only its speculative character - which would be true of almost all research in this area of environmental effects in the absence of documented sensory mechanisms - but also the small number of events vs. the many lag alternatives entering into the calculation. That is, despite their internal consistency, this may amount to capitalizing on chance effects to a greater extent than was probably the case in the other analyses and reanalyses. Conceivably, the huge flare of 4/28/1978 would assist replication. In any case, even if the effect just noted is genuine, previous cautions still apply, and it appears wholly premature to speculate on the nature of the mediating mechanisms.

In conclusion, all findings reported here from the reanalysis are statistical and cannot explain the true meaning of such relationships even within the broad framework of a non-specific adaptation model. Experts from the geophysical sciences tend to point out, in fact, that a demonstration of purely statistical associations is especially unsatisfactory in this particular area of research no matter how provocative some of the results (Jerome, 1978), and that ultimately we must seek explanations on the level of one-to-one relationships and concrete predictions.

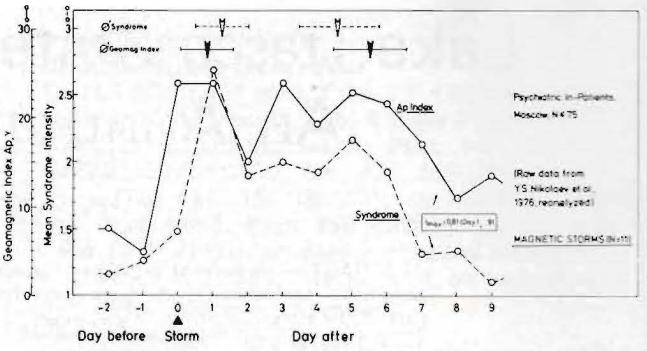

Figure 2 — Geomagnetic index Ap and syndrome intensity during magnetic storms.

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