# THE EFFECTS OF WEATHER SENSITIVITY ON STRESSED PERSONNEL

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## INTRODUCTION

Over the past decade or so the discipline of Behavioral Science has grown to include the study of biochemical effects on human behavior. In earlier days, behaviorists concerned themselves mostly with learning and conditioning phenomena, with motivation and attitude modification, and other forms of applied psychology that operated above eyebrow level. Now we are rapidly breaking new ground in the field of psychophysiology, in establishing mind/body interactions, and in developing an understanding of the important role of biochemistry in controlling brain activity--even at the level of emotional and social behavior.

Substantial impetus toward this new frontier was generated by the pioneering work of Dr. Albert P. Krueger, of the University of California, in finding a link between the electrical qualities of environmental air and blood serum levels of serotonin--a potent neurotransmitter hormone which has been closely associated with stress.

Others who follow him have succeeded in relating the balance of airborne electrical charges (ions) to the production or inhibition of other hormones, or biochemical families, and in tracing the effects of these relationships in influencing human behavior over a surprisingly broad range of emotional manifestations and physiological metabolisms.

These studies, together with the rapid advance in the technology of bioassay which enable us to objectively prove many of the links between the external environment and the internal biochemical balances, are being extended to the discovery of other environmental affectors which impact on human mind/body interactions, behavior and metabolisms.

We are now engaged in exploring the effects on behavior of such environmental factors as light, color, energy fields (sferics) and sound. And we are finding that a great many behavioral phenomena which were formerly thought to be generated above eyebrow level, are actually triggered by sensory and subsensory stimuli from the external environment.

This new class of subtle, external triggers is called "Microbiological Environmental Affectors" (MEA's), to

distinguish them from primary chemical allergens--although the two groups often have similar effects. One of these MEA's is the atmospheric ion factor, the effects of which were first observed in the context of human weather sensitivity; and the purpose of this paper is to describe how this particular factor may relate to the human factors and ergonomics of physical security.

## WEATHER SENSITIVITY AND STRESS

Considering for the moment only the ion factor, biometeorological studies indicate that about a third of any large population sample may be found "weather sensitive" to an easily measurable degree, and another third at a more subliminal level. This sensitivity is even further heightened in individuals by the presence of other forms of physical or psychological stresses which alter the normal, baseline balances of biochemical groups.

At the present state of the art of bioassay, the four biochemical groups among which such variations can be measured among the more sensitive fraction of the population are:

serotonin/endorphin - related to stress and pain;

catecholamines - related to fatigue and alertness;

thyroid factions - may relate to mental stability.

These indicated relationships are really gross oversimplifications, but may serve our immediate purpose and avoid boring you with technicalities. Also, there is a wide variation among individuals in the degree to which any one of these groups is affected; that is to say, it is most unlikely that anyone would experience irritability. fatigue, breathlessness and a touch of paranoia all at the same time, under depressive atmospheric conditions.

In analyzing the biodynamics of these effects, weather-change vectors were identified as:

temperature,

humidity,

atmospheric pressure,

electrostatic field gradients,

+/- gaseous ion balance.

But experimental evidence indicates that within its normal range of meteorological excursions, each of these vectors can be eliminated as the basic cause of such biochemical shifts except the ion balance factor.

Among those individuals who exhibit observable forms of weather sensitivity--or perhaps we can call this "ion sensitivity"--under suboptimum ion balance conditions, nearly half (44%) show serotonin-related symptoms dominantly, and a like proportion experience catecholamine-related symptoms. Only about 13% show signs of interference with thyroid metabolism resulting in irrational behavior, and this usually develops only after several hours in the depressive atmospheric environment when other stresses are present. In addition to these specific effects, there is evidence of an overriding prostaglandin disbalance (related to blood circulation and respiration problems) which may affect a large but undetermined fraction.

## ION DYNAMICS

There are, of course, many kinds of ions in solids, liquids and gasses; for our purpose we will consider only the class of monomolecular, gaseous ions which interact electrically at the surface of living tissue. In this context, a negative ion is a neutral molecule (usually $O_2^-$) which has captured an extra free electron and is attracted to any other molecule or surface with a more positive charge, where it delivers over its extra electron and becomes neutral again.

Conversely, a positive ion is a molecule which has had one of its normal complement of electrons knocked away by some nearby, random, subatomic event; then it is attracted toward any more negatively charged surface where it can easily replace its missing electron at a low energy level.

Both positive and negative ions are being created continuously by the various forces of nature, but they are usually short-lived because they are continuously being reneutralized by this process of electron change.

Let's assume, for example, that during one inspiration a million negative ions enter the respiratory system, and each one delivers up its extra electron to the surface tissues of the bronchi and lungs. These million newly liberated electrons would tend to travel into the deeper tissues of the body in the form of a disperse current flow. This would tend to affect the electrical fields of cells involved in the manufacture of biochemicals and to influence the metabolism of these biochemicals.

I say "tend to" because during the same inspiration, perhaps a million positive ions also enter the respiratory system, and each of these borrows an electron from the tissue surface it encounters. These electrons would be replaced at the surface from deeper tissues and tend to start a disperse current flow *out of* the body; but in this case, where the effects of the positive and negative ions are equal and opposite, the net current flow would be zero.

So it is only when there is a prepondernace of either positive or negative ions that this electron-exchange phenomenon results in electrochemical effects in the deeper tissues, and so alters the orchestration of our complex biochemical systems.

In fresh, outside air during fair weather, there are roughly equal concentrations of +/- ions; we consider this as normal, or baseline, ion balance. However, preceding every storm (sometimes by as much as a day or two, depending on the severity of the storm) there is a substantial-to-massive increase in the concentration of positive ions, which has a "negative" effect on ion-sensitive people. This is why some folks become irritable, dull-witted, less productive, depressed or more sensitive to pain under prestorm conditions, especially when they are supporting other forms of stress.

After the storm, this air-ion disbalance is quickly reversed, and there is an overabundance of negative ions. This not only relieves the symptoms of positive-ion depression, but often produces euphoria, heightened vitality, alertness, enhanced sensory acuity and--if we can extrapolate the observations of animal breeders--heightened sexual drive.

Knowing this, a field commander might achieve a slight tactical edge by artificially charging his personnel with negative ions and attacking the enemy just before a major storm, given a good meteorologist on his staff.

But weather effects are transitory and seldom comform to the order of battle, although it might be useful to keep them in mind when major storms are in the offing. What is of significance here, however, is that we are just beginning to recognize the fact that with our modern, efficient architecture, we are creating artificial working environments in which we have very often *simulated* the most severe prestorm, high-positive-ion conditions, to the serious detriment of a certain number of our personnel working under stressful conditions which inevitably are situations requiring very high levels of vigilance, sensory acuity and fast reaction time or, for that matter, the exercise of high levels of intelligence in planning and command tasks.

## CONTINUOUS PRESTORM IONIZATION CONDITIONS CREATED IN MAN-MADE STRUCTURES

The architecture of watchowers, interior guard posts[1], control[2] and communications rooms[3] is generally highly space-efficient, particularly in windowless, hardened sites. This is also true of patrol vehicles and armor[4]. These environments always include some combination of other factors, each of which contributes either to the reduction of negative ions, the increase of positive ions, or both. The magnitude of the resulting shift in ion balance often greatly exceeds that of natural, prestorm conditions, to the point where measurable performance degradation can be observed among personnel working in such environments for hours at a time.

Some of the factors which contribute to this effect are:

inadequate window area or very thick windows;

forced-air circulation through ducts;

wind friction on external building (or vehicle) surfaces;

air-conditioning and filtering equipment;

fluorescent lighting fixtures:

low ceilings (8' or under);

electrical equipment (radios, displays, typewriters);

synthetic floor surfaces and ceiling materials;

tobacco smoke;

large metal furniture (cabinets, safes, desks, etc.)

Numerous measurements made with laboratory instrumentation in such typical environments, and also in closed vehicles, provide objective evidence of massive ion-balance deficiencies and support the subjective reports of personnel working therein. For example--and this is only one of many instances--in the Spring of 1978 I was invited to make ion measurements in the Defense Nuclear Agency office suite occupied by Marvin Beasley's officers and colleagues.

At 2:10 p.m., immediately prior to these tests, measurements were made in the fresh, outside air in a shady area on the lawn outside the DNA Headquarters; we found a

positive ion count of 1,110 ions per cubic centimeter of air, and a negative count of 960/cc. This indicated a +/- ratio of 1.16:1, which is quite normal for fair weather conditions in a rural environment, and a total ion count of 2,070/cc (a parameter which is of long-term biological significance).[5] At about 2:20 p.m., in the testing area, we measured about +80/16, or a ratio of 5:1 and a total of 96 ions/cc, or about 6% of an acceptable, healthful level. In fact it was difficult to determine values accurately so low on the scalar levels of the instruments.

After taking these measurements, I interviewed the personnel and learned that about half of them were aware of becoming progressively more inefficient and dull-witted towards the end of the day; this was particularly true of the nonsmokers affected by the heavy output of tobacco smoke without benefitting from the stimulation of the nicotine, and it was also noted that the coffee consumption of this group was unusually high with respect to the norm among personnel on other floors of the building with well-windowed and more spacious offices.

Apart from the professional and scientific interest of these officers and civilians, another purpose of this test was to evaluate the need for the installation of electronic negative ion generators, to restore a more natural ion balance and increase the very low total-ion count. Two such devices were subsequently tested on a loan basis, and the observed environmental improvement was determined to justify procurement requisitions which were submitted in due course. Unfortunately for these personnel, however, acquisition was vetoed by someone sitting in a spacious, airy office upstairs.

This brings up the point that not everyone is aware of being affected by unnatural ionic conditions, probably because their autonomic biochemical control systems are capable of compensating for these effects. So it is understandable that people not continuously subjected to poor ionic environments, and also ion-insensitive individuals usually find it difficult to sympathize with the sensitives, or to accept the fact that such effects exist. There appears to be a genetic factor involved in ion-sensitivity, which is often reflected in body type and evidenced in sustained levels of task performance or work output.

A typically ion-insensitive individual is characteristically found to have a sturdy skeletal structure and body-build, and a brachycephalic skull configuration. Marv Beasley, whom we all know, is an excellent example; he is also capable of working effectively in that difficult office environment for hours after his colleagues have left in a miasma of fatigue. Although apparently insensitive to ion balance effects himself, it is a tribute to his keen

perception that he recognizes such effects may occur among the tall, thin, narrow-headed or corpulent body-types among which ion sensitivity appears to be common. I trust he will forgive me for using him as an example in the interests of behavioral science, of which he has always been a strong proponent.

## ION SENSITIVITY COUNTERMEASURES

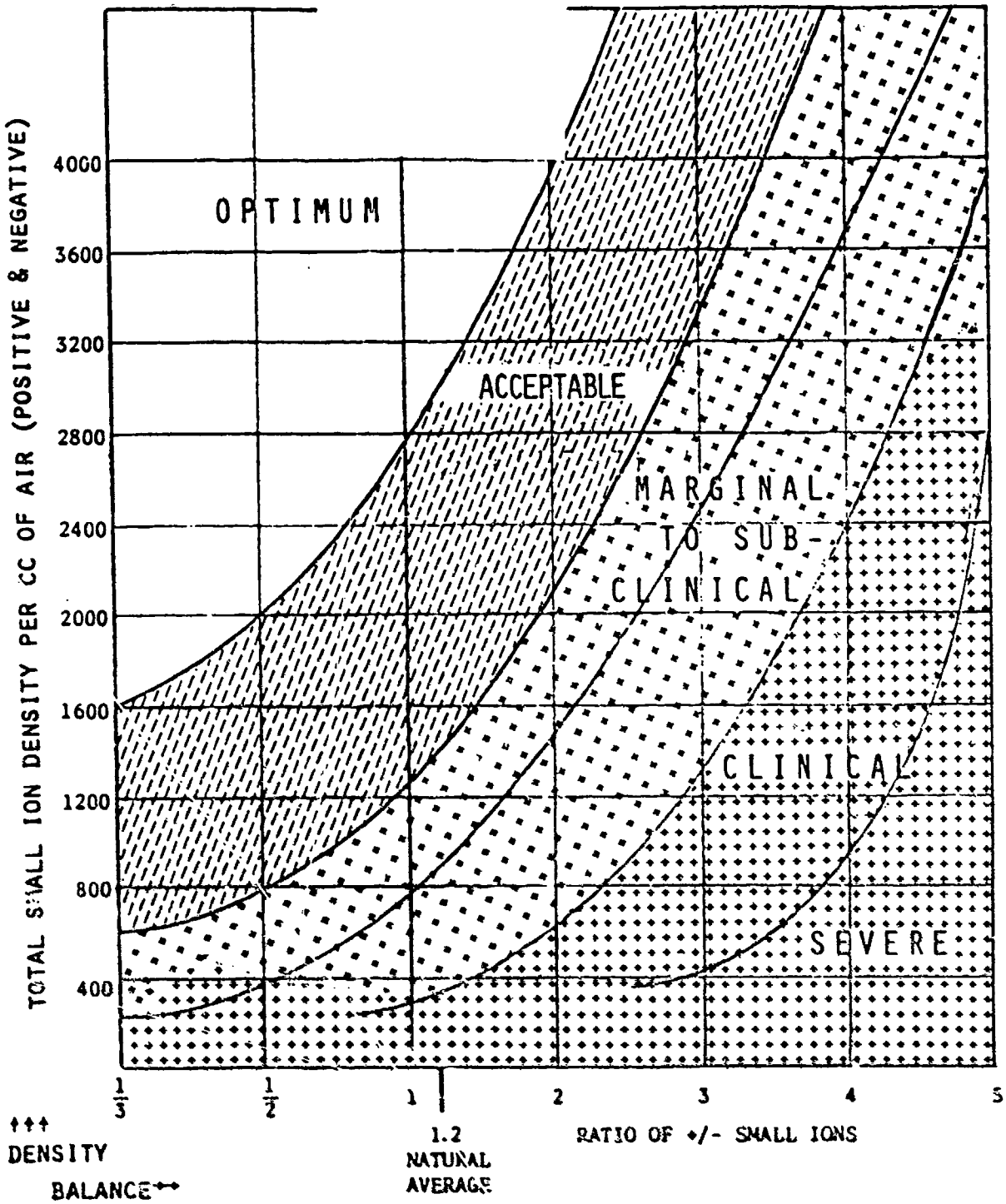
Where deviations from acceptable ion densities and/or balances are observed to exist in working environments, they can be countered effectively and economically by the installation of suitable electronic devices which create negative ions to offset high attrition rates in poor ionic environments. Concurrently with the spread of information on the biological effects of air-ion balance in journalistic media, there has been a proliferation of poorly designed ion-generation systems brought into the market; these have been responsible for enough disappointing experiences among the nontechnical public to somewhat slow general acceptance of the technology. But high-quality, professional devices are available for these applications at a cost of $1 or less per square foot of working space coverage.[6]

Negative ion concentrations produced by these devices vary geometrically with distance from the source and are also affected by local air currents; but quantitative measurements are not critical to the application within their effective range of six to ten feet, as there are no harmful side-effects from large concentrations of negative ions[7] -- which often achieve 20 to 40 times baseline levels under natural conditions at seashore sites, in pine forests or nearby waterfalls.

Figure 1 is a matrix of weighted values compiled from the medical literature and may serve as a useful guide to acceptable levels in working, standby and living environments.

In the profession of physical security and safeguards, it is not possible to quantify the value of human performance quality; a small increment of degradation may be analagous to the proverbial horseshoe nail that lost the Battle of Hastings. To lend some perspective, let's assume that one quarter of a given guard force is made up of ion-sensitive individuals, and that under adverse weather or ion-environmental conditions we can measure an average of 20% vigilance degradation; these figures are very conservative with respect to actual field observations.

This represents an overall 5% reduction in force effectiveness which, if sustained over long periods, begins to impact on that subtle factor of motivation but may not




ESTIMATED ION DENSITY/BALANCE BOUNDARIES OF EFFECTS ON 30% (-4 to -1 S.D.) OF ANY LARGE GENERAL GROUP AFTER 4 HRS EXPOSURE

FIGURE 1

N.B. TOTAL ION DENSITY RELATES TO LONG-TERM METABOLIC EFFECTS SUCH AS SODIUM/POTASSIUM LEVELS. +/- BALANCE RELATES TO SHORT-TERM BIOCHEMICAL EFFECTS MORE RELEVANT TO THE EFFECTS DISCUSSED IN THIS PAPER.

otherwise look like a major threat. On the other hand, in Don Richard's scenario with the fishpole, the sensitive group *on the average* might start ignoring a signal after the fourth false alarm instead of after the fifth; again, this may not seem of great importance. But consider the one or two individuals in this sensitive group at the extreme of the sensitivity range (S.D. = 8%) whose performance may be degraded by 50% or 60%; these are the ones whose performance profile will reveal the greatest vulnerability; they're the ones who are most apt to go off half-cocked and fire the unnecessary shot that starts the war.

Of course these highly ion-sensitive individuals should never have been assigned to such critical duties in the first place, which brings us to the excellent arguments advanced by Clare Goodman for the development of an ergonomics data system to meet the requirements of personnel selection in physical security tasking. Gross probability of individual ion balance susceptibility should not be difficult to evaluate, and there appears to be good justification for using this parameter in the selection process. Early fatigue is another dominant characteristic of ion sensitivity (43% incidence of the catecholamine syndrome), and Larry Ewing's remarks about fatigue in his shipboard behavioral model offer additional justification for ergonomic measurements of ion sensitivity, particularly as this is closely related to stress-level by virtue of the serotonin connection.

It may be some time before we arrive at the point where we can eliminate hypersensitive and hyperstressed personnel from critical task assignments under potentially suboptimum ionic conditions; in the meantime, there are electronic devices and systems available to improve the quality of such environments and lessen the constant threat of human fallibility in critical security tasks. Some immediate applications of these devices which may be of interest to this symposium are:

GUARD POSTS - to enhance vigilance[1][2][8] and sensory acuity[9]

PATROL VEHICLES - to minimize reaction time[4]

CRISIS CENTERS - alertness; minimizes brain-fog and fatigue of sustained tension (and tobacco smoke fog)

DECONTAMINATION - rapid precipitation of airborne particles[10] and acceleration of lung clearance through biological action (radioactive particles)

WOUNDS - reduces trauma shock and accelerates recovery from blood loss[11]

DETENTION FACILITIES - reduces stress-induced disciplinary problems and the spread of airborne respiratory diseases

It is noted parenthetically that Daryl Solomonson's investigation of behavior in watchtowers revealed a common syndrome of troublesome discomfort and nausea in windy weather; this is attributed to tower sway by association rather than through any objective evidence. In fact, the friction of wind on the metal housing imparts a positive electrostatic charge which, inside the enclosure, quickly attracts and depletes the negative ion population. This is the same phenomenon that occurs in moving vehicles, and accounts for a large fraction of motion sickness problems. Many such sufferers have found that the use of a small generator to replace the depleted negative ions will prevent the onset or relieve the severity of these symptoms. I do not suppose, however, that this would be helpful in nausea induced by vertigo, which involves a different set of neurophysiological dynamics.

## NEAR-TERM RESEARCH OPPORTUNITIES

Our analysis of the literature indicates that up to 20% of a healthy, military force may be transiently affected by ion shifts up to 48 hours prior to and during storms and sustained high winds. The specific effects involves degradation of vigilance, sensory acuity, reaction time, mental alterness and stamina. The personnel screening and selection process for assignments requiring optimum performance in these behavioral areas does not now include accessable physical parameters of weather sensitivity because these have not been adequately evaluated and defined. Some promising starts have been made in this direction, which indicate potentially useful approaches to the rapid development of suitable ergonomic standards if this effort is given appropriate support.

More significantly, up to 65% of the personnel working and/or living in enclosed artificial environments (buildings or vehicles) under poor ionic conditions probably experience similar performance degradations which increase at varying rates with exposure duration. As ergonomic screening such a large group would not be feasible, the more practical and economical alternative of artificially restoring normal ion balances is the indicated countermeasure. Our research targets whould therefore include:

1. evaluation of +/- ion ratio thresholds to establish boundary conditions and acceptable exposure intervals;

2. quantitative analysis of effects and susceptibility index of typical populations;

3. development of architectural standards to minimize deleterious ion balance conditions;

4. application engineering standards for determining specific space requirements for negative ion generation equipment;

5. ion generator equipment design and performance specifications for (a) preliminary research efforts, and (b) field use.

These are not listed by priority, as there is some interdependence among these efforts and the different disciplines involved.

Decisions and Designs, Inc. (DDI) is currently tasked by DNA to explore the application of ion technology in the intrusion-detection modality, as some of these devices have proven to be highly effective sensors in this application. This development will be reported elsewhere, as it does not relate to behavioral science; however, in the performance of these task requirements, DDI has developed an exceptionally fine air-ion measurements laboratory and an extensive background in the basic physics and technology of ion generation. It is hoped that organizations investigating the biological effects of air-ion balance and density will be able to make effective use of this resource.

## THE SHAPE OF THE FUTURE

In discussing the effects of weather and ion sensitivity on stressed personnel, we are focussing only on the transient effects of a single facet of Microbiological Environmental Affects (MEA's) mentioned in my introductory remarks. There are a number of other significant MEA's--light spectra, sound, olfaction, energy fields (sferics)--which impact upon the human biochemical systems in varying, individualistic fashions to shape behavior. Under modern environmental conditions where these effects are sustained more continuously, rather than peculiar to a short-term working environment, they may bring about long-term cumulative behavioral changes which begin to affect social structures when a large enough fraction of the population is involved.

This is precisely the case where both working and living environments in modern, urban and suburban or institutional settings are suboptimum or worse with respect to MEA factors.

As new population groups undergo a transition from their accustomed, traditional, rural living environments to life in crowded, noisy poorly ventilated and ill-illuminated quarters in urban, inner-city or fringe-area slums, much high incidence of MEA-sensitivity will be found among the unhabituated groups. In terms of social stresses and behavioral patterns, this impacts particularly on the younger population in growth and maturation stages. Such groups may require a generation or more to adapt to the biochemical shifts triggered by the MEA's of new environments, and the resulting psychological stresses may be evidenced in ways which become statistically apparent to the social scientist.

For example, at least some part of the inexorably rising crime rate among the 14-34 year segment of inner-city populations in this country could conceivably be linked to lack of adaptation to stress-inducing MEA's. Similarly, the progressive increase in terrorism observed in emerging countries, where urbanization is proceeding rapidly among low-income, pastoral populations, could conceivably be linked to novel environmental factors.

This suggests the possibility that there may be a *biological* factor involved in the rise of crime and terrorism, which is being manifested as heightened social stresses among a portion of the younger generations.

Evidence at hand is sufficient to warrant investigation of this possibility on a broad, multidisciplinary scale, in the interests of shaping peaceful, productive societies. It is in areas such as this that behavioral science may have substantial contributions to make in shaping the future.

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