INTERDISCIPLINARY DEVELOPMENTS IN HAZARDOUS ENVIRONMENT RESEARCH: A SILENT TRIBUTE TO GENERAL SYSTEMS THEORY?

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ABSTRACT

Purpose: This paper draws attention to a welcome trend in certain areas of applied and experimental research that appears to endorse a General Systems Theory for the acquisition of knowledge. ***Method:*** By way of illustration it makes an appraisal of key studies of human/environmental interaction that were either derived from actual operational groups in naturalistic settings or contrived in the laboratory or the field to simulate extreme conditions. ***Results:*** It urges more anthropologists, physicians, physiologists, psychologists, and sociologists to follow suit and make their disciplinary boundaries permeable. Were they to do that, it is argued that their research methods would be more appropriate for studying the dynamic integration of their subject matter than those derived from the conventional use of scientific method. ***Conclusions:*** It asserts that the solutions to complex problems of human adaptation to the environment are not to be found within the domain of any single academic discipline. *(Int J Circumpolar Health 2002; 61: 216-223)*

This paper originated in 1995 as an invited address to the First All-India Conference of Physiology that was held in New Delhi. At the time the Indian Antarctic Research Programme was bearing fruit (1), and before embarking on a more ambitious multidisciplinary plan for the investigation of human adaptation to polar conditions, its researchers wanted to consider the conceptual and methodological issues they might encounter. Although the scientists were from the conventional tradition that was more laboratory-based than clinical, naturalistic, and observational, in essence they accepted Crick's (2) trenchant criticism of reductionism, and they were inclined to favour the early Baconian commitment to the integration of knowledge rather than its fragmentation (3).

To give but two glaring examples: in the 1960's biological researchers conducted isolation studies in a specially con*structed* Tier Bunker facility at the Bavarian Max Plank Institute where they measured the dietary, hormonal, and

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gross body movements of subjects for a month at a time (personal observation September 1975). The scientists were very productive (4-5), but they ignored the cognitive, emotional responses of the subjects, and they conducted no follow-up studies that might have identified any adverse side-effects from the sensory-isolation experience (6).

The around the same time NASA ignored behavioural science in its preparation for long-duration space flights, except for discerning the preference of crews for elements capsule design and decoration (7). The entire four and a half year Skylab Project that was designed to test 'the broadest sense of survival (and) the ability to live …effectively in the environment' contained not one single psychological component. Instead, the physiologists adopted an exclusive bioengineering approach as they addressed shifts of body fluids, muscular tone, vestibular balance, orientation, sleep patterns, and circadian rhythms of their astronaut subjects (8). The implication was that humans could perform effectively for long periods in space if only their physical health were properly maintained and their bodily were needs satisfied.

Encountering such conceptual and methodological constrictions warrants a rare excursion into epistemology - the philosophy of procedures by which knowledge is acquired – in search of pointers to the way ahead. The intellectual journey could begin with a reconsideration of the reformulation of Kuhn's fundamentals (9) and led to an indulgence in Hellemans and Bunch's (10) assembly of historical facts from diverse fields of scientific endeavour. The one highlights the conceptual changes that with a fresh eye could be seen to have occurred in the history of science, and the other strings the major contributions of science together with more regard to their significance than their disciplinary source. Neither espouses a hierarchical framework to perpetuate the ascendancy of any single scientific discipline or narrow cluster of such disciplines in the acquisition of knowledge.

Conceivably the separation of scientific disciplines arose from a need to break the enormous web of potential topics into manageable component parts (11 pp.46-59). It inspired Linnaeus in the 18th Century to develop his comprehensive system for the classification of plants and animals, and Haeckel in the 19th Century to put forward his genealogical tree of human development (12). Haeckel

went further to separate the study of humans into that of structure (morphology) and of function (physiology) before further dividing the one into anatomy and development and the other into internal and external functioning. Charles Darwin and Alfred Wallace came along soon after with a broader canvas to consider the corresponding differences in the environment and their influence on human evolution. But the clash that inadvertently they created postponed any attempt that might soon have followed to integrate the emerging disciplines of science.

Integration

Bertalanaffy (13) was among the first to proclaim the integrative theme for the conduct of scientific research. His conceptualisation promised eventually to combine the disparate findings from studies of cells, micro-organisms, organs, organisms, groups, organisations, communities, and beyond. Then more recently Miller (14) restated a Living Systems Theory (LST) to an interdisciplinary audience of scientists that was involved in either polar or outer space research. He described LST as 'an integrated conceptual approach to the study of biological and social living systems, the technologies associated with them, and the ecological systems of which they are all parts', and he described the goal of research on LST as collecting data 'to make deductive tests of hypotheses derived from inductive, integrated theory'.

Among the supporting presentations were papers that exemplified the application of the very theory he espoused - i.e. the International Biomedical Expedition to the Antarctic (IBEA) (15). The IBEA was a comprehensive, extensive, and perhaps expensive project constructed solely for the purpose of studying human adaptability to the hostile climate of Antarctica. It derived questions from clinical medicine, physiology, psychology, and psychophysiology that had a bearing on the effects of geographical isolation and group insulation. It involved a comprehensive range of field studies in French Antarctic Territory as well as a non-stop battery of before and after laboratory studies in the Commonwealth Health Laboratories in Sydney. It had naturalistic, psychometric, and experimental features that involved both within-group and between-group effects. The naturalistic features were monitored during the

normal course of fieldwork. The psychometric features related to the measurement of certain personal, interpersonal, and group predictive criteria.

The independent variables in the laboratory consisted of a routine of cold baths and noradrenaline for one of two randomly assigned matching groups to see if they might readily assist in acclimatisation to the cold. Those in the field had the subjects all exposed to the climatically hostile Antarctic environment under rigorous living conditions, in search of a general factor of bio/medico/social stress. The parameters under measurement included blood and urine, skin flora, perspiration and heat flows in hot and cold chambers, perimeter body chilling, blood-flow recording, heat exchange, respiratory capacity, work output, sleep patterns, reaction times, decision-making, dietary intake, symptom development, personal perceptions, attitudes, interpersonal behaviour, and group relations. Samples were taken at predetermined times according to a complex schedule of programmed activities. The data were recorded through appropriate biochemical, chemical, electronic, electrophysiological, observational, photographic, and psychometric procedures.

There were 12 subjects, ten of which had considerable previous experience of snow and ice conditions. Eight were medically qualified researchers and the remainder consisted of a biochemist, a physiologist, a psychologist, and a technician. They were drawn from Argentina, Australia, Britain, France, and New Zealand, with English as a common language. For logistic reasons and to minimise costs, they were selected for their experimental expertise and readiness to switch roles and become experimental subjects as occasion demanded. All were volunteers, few of whom were really aware of the commitment they had made. Typically they had agreed to participate as subjects in the hope that their colleagues would reciprocate by obliging them when their turn came to conduct their own experiments. Few had ever been in such a role, and none had taken part in a demanding and sustained experimental routine.

In Sydney, the subjects were quartered in close proximity but were left to their own devices in what spare time their busy routines allowed. But once in Antarctica, they travelled on open-skidoos in randomly assigned pairs for periods of 14 days, towing their own sledges with standard gear as they moved to prearranged sites at which they

would stop for the predetermined data collections. They slept in small tents, and cooked their own meals from basic rations.

Suffice to say, the incidental, intrusive, and invasive procedures involved in the experimentation had a greater impact on individual and group performance than did the frigidity of the Antarctic climate. The cold baths had only a temporary effect in facilitating the adaptation of the experimental group to the cold of Antarctica, and the stringent conditions imposed on the group as a whole evoked few decrements - except in terms of their adverse personal and interpersonal reactions. The most serious of the personal reactions induced clinical depression in a subject and caused him to be evacuated from the field. The most serious of the group reactions led a few subjects to withdraw from the follow-up phase of certain experiments and procedures.

Thus the outcome of the IBEA indicated that the personality factors of ability, stability, and compatibility were as relevant for the selection of scientists that undertake isolation studies as for any other people that might be involved as subjects in their studies (16). It showed that research designers needed to give as much consideration to the cumulative and stressful effects of the extensive pattern of experiments they plan to conduct as to any stressful effects the environment might have on their subjects. It made clear that scientists needed to be trained in the application of general systems theory, and in the integration of data from their separate studies. Finally it showed that whether scientists were in the role of experimenters or subjects they needed to be trained in methods of conflict resolution (17).

Further developments

Despite its shortcomings, the IBEA broke the ground for future interdisciplinary and international research on projects in hostile environments (18-20). After one small group study Taylor, Van Dorp, Oude-Alink, & Kennaway (21) reported some of the psychological and physiological components of extreme tension that prevailed in a four-person Greenpeace party that wintered-over at the smallest Antarctic base: in the process monitoring performance and gathering questionnaire data in real-time by computer and satellite from a remote area on one continent to a

metropolitan laboratory in another (22).

In a larger longitudinal and epidemiological study of US Antarctic winter-over personnel, Palinkas (23) found that although depression, insomnia, hostility, and anxiety commonly featured in their phasic reactions in Antarctica, on return home they were not at greater risk of hospitalisation than their controls. Some in fact showed an enhancement in performance. Suedfeld (24) made similar observations from his polar research, and he invoked Antonovsky's (25) concept of 'salutogenesis' to describe the benefits that some people derive from the experience of apparent hardship.

Subsequently Palinkas (26) and his group found a direct association between the same adverse emotional reactions and an increase in serum TSH levels and an inverse association between high levels of fatigue and confusion and an increase in FT3 levels. They also found that the lack of group cohesion had a negative effect on mood states.

The relevance of such interdisciplinary Antarctic research was not lost on the new generation of behavioural scientists involved with the US space research programme (e.g. 27-28). Gradually they developed coordinated programmes that used both the Antarctic and simulated isolation and confined environments (ICE) as analogous situations for the proposed long duration space flights (29-33). But their studies still needed to be integrated firmly with those of biological scientists.

Resistance

However isolation researchers in Europe made little mention of the findings from Antarctica in their report of the 28 days study of six subjects in a submersible off Norway (34). Although the interdisciplinary experimenters in that study purported to have adopted an integrated design, they seem to have kept their distance from each other as physiologists, psychologists, telecommunication experts, and toxicologists. In particular some of the physiologists complained of 'having to jostle for priority, to search for a niche in a complex programme of activities, to delegate measurement to 'trained laymen (and) even then .to cooperate with all these other colleagues whose data will merge with his data' (35). They also commented that it was difficult to determine whether the psychological or the

REFERENCES

1. Sachdeva U, Naidu M, Chhajer T, Rai T, Sandaresuan G. Temporal pattern of hormonal levels and autonomic status of men during their prolonged stay in Antarctica. (Unpublished presentation to a meeting of the Working Group on Human Biology and Medicine of the Scientific Committee on Antarctic Research, Rome, July 1994.
2. Crick F. The astonishing hypothesis: The scientific search for the soul. London: Simon Shuster, 1994.
3. Colverson T. ed. The roots of modern environmentalism. London: Routledge, 1989.
4. Aschoff J. ed. Circadian clocks: Proceedings. Amsterdam: New Holland, 1965.
5. Aschoff J. ed. Biological rhythms: A handbook of behavioural neurobiology. New York: Plenum, 1981.
6. Bexton WH, Heron W, Scott TH. Effects of decreased variation in the sensory environment. Canad J Psych 1954; 8: 70-766.
7. Taylor AJW. Behavioural science and outer space research. Aviat Space Environ Med. 1989; Aug: 815-816.
8. Johnston RS, Dietlin LF. eds. Biomedical results from Skylab. Washington DC, NASA, 1977.
9. Kuhn TS. The structure of scientific revolutions. 2nd edn. Chicago: Univ Chicago Press, 1970.
10. Hellemans A, Bunch B. The timetables of science: A chronology of the most important people and events in the history of science. New York: Simon Shuster, 1988.
11. Pepper D. The roots of modern environmentalism. London: Routledge, 1989.
12. Bates M. Human ecology. In Kroeber AL. ed. Anthropology today: An encyclopaedic inventory. Chicago: Univ Chicago Press, 1953; 700-713.
13. Bertalanaffy von L. Problems of General System Theory. Hum Biol 1951; 23: 302-311.
14. Miller JG. Applications of Living Systems Theory to life in space. In Harrison AA, Clearwater YA, McKay CP. eds. From Antarctica to outer space: Life in isolation and confinement. New York: Springer-Verlag, 1990; 177-198.
15. Rivolier J, Goldsmith R, Lugg DJ, Taylor AJW. eds. Man in the Antarctic: The scientific research of the International Biomedical Expedition to the Antarctic. London: Taylor Francis, 1988.
16. Taylor AJW. Antarctic psychology. Wellington: DSIR Science Information, 1987.
17. Cornelius H, Faire, S. & Hall, R. Conflict resolutions: An eight session course.

Chatsworth, N.S.W., Australia: Conflict Resolutions Network, 1990.
18. Peri A, Barbarito M, Barattoni M, Abraham A. The dynamics and the interpersonal and intrapersonal relations within an isolate group in extreme environments. Small Group Res 2000; 31(3): 251-274.
19. Peri A, Scarlata C, Barbarito M. Preliminary studies on the psychological adjustment in the Italian Antarctic summer campaigns. Environ Behav 2000; 32 (1): 72-83.
20. Australian National Antarctic Research Publications in Medical Sciences. Hobart: Polar Med Branch, 1994.
21. Taylor AJW, Van Dorp CF, Oude-Alink P, Kennaway DJ. The personal and interpersonal dynamics of a small Antarctic winter party, with some physiological concomitants. In Humphrey J. ed. Recent developments in human stress research. New York: AMS Press, 2001; 21-29.
22. Taylor AJW. The collection and transmission of data by computer and satellite. In Guo Kun. ed. Proceedings of the International Symposium on Antarctic Research. Tianjin: China Press, 1989; 355-359.
23. Palinkas LA. Effects of physical and social environment on the health and well-being of Antarctic winter-over personnel. Environ Behav 1991; 23: 782-789.
24. Suedfeld P. Stimulus restrictions in the field and the laboratory: The search for analogies. SPRI Polar Symposium 1991; 1: 35-38.
25. Antonovsky A. Unraveling the mystery of health: How people manage stress and stay well. San Franciso: Jossey Bass 1987.
26. Palinkas LA. Psychological factors and the seasonal affective disorders. Reports of the Conference on Polar and Alpine Med 1999; 11-22.
27. Harrison AA. Clearwater YA, McKay CP. eds. From Antarctica to outer space: Life in isolation and confinement. New York: Springer-Verlag. 1990.
28. Stuster J. Bold endeavours: Lessons from polar and space exploration. Annapolis MD: Naval Institute Press, 1996.
29. Palinkas LA, Gunderson EKE, Holland AW, Miller C, Johnson JC. Predictors of behaviour and performance in extreme environments: The Antarctic Space analogue programme. Aviat Space Environ Med 2000; 71(6): 619-625.
30. Palinkas LA, Gunderson EKE, Johnson JC, Holland AW. Behaviour and performance on long-duration spaceflights: Evidence from analogue environments. Aviat Space Environ Med 2000; 71(9) 29-36.
31. Peri A. ed. First Italian Workshop on Human

physical factor was ultimately responsible for the observed changes.

The comment about the continuing search for the single 'ultimate' factor, the Holy Grail of 19th Century science, confirms that reductionism dies hard. The shock of working collaboratively instead of in competition might have been too much for the purists to bear. For them the interactive project was not a learning exercise. For the outside observer it raises questions about the need to modify the curriculum of both Medical Schools and post-graduate refresher colleges to incorporate an interdisciplinary interactive model in the conceptual orientation to problem solving.

Recognition of psycho/social factors

In 1986 the WHO was sufficiently committed to the comprehensive approach that it redefined health as a complete state of physical, mental, and social well-being. In doing so, it encouraged research into the interactions of mind, body, and social environments. The outcome led to a flourishing interest in psychosomatic medicine (36) and to the endorsement of the pioneering work of Selye (37) in the field of stress (38-40). The problem was to identify the biological markers (41) as well as the psycho/social markers (42).

Since then much progress has been made in rendering objective the subtle and subjective but important generators of the phenomenon (43-44). Ursin (45) also advanced the challenging proposition that the autonomic and the hormonal systems are interactive rather than separate, and that a combined sensitisation and cognitive arousal theory might provide the most acceptable explanation to account for serious neuro/psycho/biological conditions in which they are activated.

CONCLUSION

Responses to environmental stressors cannot be predicted by measuring the physical characteristics of the stimulus alone. Prediction requires knowledge of the way individuals perceive the stimulus, how they interpret it, and how their individual and group motivations and behaviour affect

their responses. Contributions to knowledge about human behaviour in any environment need to be seen as part of a dynamic general matrix of variables, the appraisal of which requires the effort of committed researchers from many disciplines. The outcome is more likely to be to approximate the characteristics of multi-faceted human performance than any more restrictive research programme.

The point is not to deny the importance of well conceived and carefully controlled laboratory based segmental studies, but to remind researchers that the outcome has to be related ultimately to that from other research domains and be tested in reality situations.

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Adaptation in Antarctica and extreme environments. Venice: PNRA. 2000, pp.122.
32. Stuster J, Bachelard C, Suedfeld P. The relative importance of behavioural issues during long-duration ICE missions. Aviat Space Environ Med 2000; 71(9): 17-25.
33. Suedfeld P, Steel GD. The environmental psychology of capsule habitats. Ann Rev Psychol 2000; 51: 227-253.
34. Bonting SL ed. Advances in biology and medicine. Vol. 3. European Isolation and Confinement Study. Greenwich, CON: JAI Press, 1993.
35. Gunga HC, Maillet A, Kirsch K, Röcker , Gharib C, Værnes R. Water and salt turnover. In Bonting SL ed. Advances in biology and medicine. Vol. 3. European Isolation and Confinement Study. Greenwich, CON: JAI Press, 1993; ch 13.
36. Carson RC, Butcher JN, Coleman JC. Abnormal psychology and modern life. 4th edn. Glenview Il: Scott Foresman, 1988.
37. Selye H. Stress in health and disease. London: Butterworths, 1974.
38. Ursin H, Olff M. The stress response. In Stanford C, Salmon P, Gray J. eds. Stress: An integrated response. London: Academic Press, 1993 (a); 3-22.
39. Ursin H, Olff M. Psychobiology of coping and defence strategies. Neuropsychobio 1993 (b); 66-71.
40. Ursin H. ISEMSI: A space psychology experiment. Adv Space Bio Med 1993; 3: 23-34.
41. Theorell, T. Notes on the use of biological markers in the study of long-term stress. In Carson JA, Seifert AR, Birbaumer N. eds. Clinical applied psychophysiology. London: Academic Press, 1994, 251-260.
42. Cox, T. Stress research and stress management: Putting theory to work. HSE Contract Research Report No. 61/1993. London: HMSO.,1993.
43. Eriksen HR, Ihlbaek C, Ursin H. A scoring system for subjective health complaints (SHC). Scand J Pub Hlth 1999; 27: 63 -72.
44. Eriksen HR, Olff M, Ursin H. Coping with subjective health problems in organisations. In Dewe P, Leiter M, Cox T. eds. Coping, health, and organisations. London: Taylor Francis. 2000, ch. 8.
45. Ursin H. Psychosomatic medicine: The state of the art. The Finnish Medical Society Duodecim, Annal Med 2000; 32: 323-328.