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Physiological and psychological patterns of acute and chronic stress during winter isolation in Antarctica

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University of California, Irvine, 1990

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IRVINE

Physiological and Psychological Patterns of Acute and Chronic Stress During Winter Isolation in Antarctica

DISSERTATION

submitted in partial satisfaction of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in Social Ecology

by

Sybil Carrère

Dissertation Committee:

Professor Gary W. Evans, Chair

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1990

The Dissertation of Sybil Carrere is approved,

and is acceptable in quality and form

for publication on microfilm:

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1990

DEDICATION

To

my husband, James Joseph Stretch.

You believed in this research every step of the way.

I welcomed your shoulder of support when I didn't think

I had what it took to complete the dissertation.

I offer you my heartfelt appreciation now that this work has come

to fruition.

And also to

My very dear winter-over comrades

who dedicated seven months of time and energy

to make this research possible.

"You were relentless!"

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Each member of my dissertation committee has made a major contribution to my graduate education and dissertation research:

Neil Grunberg made the time and space available for me to come to the Uniformed Services University of the Health Sciences so that I could learn about the role of catecholamines in physiological arousal. He made it possible for me to learn how to conduct catecholamine and cortisol assays. He also made his laboratory available for me to do the assays required by my dissertation. This amazes me! He is a rigorous, pedagogical task master with a generous heart. I admire Neil greatly for both of these qualities.

Dick McCleary was instrumental in teaching me time series analysis before he even got to UC Irvine. His book and writings translated a statistical mystery into a set of analytical techniques that offered a different way of looking at stress processes. Imagine my delight when Dick joined the Social Ecology faculty. Always rude and irreverent, completely kind and good-hearted, Dick McCleary held my hand and offered guidance as I trod the dreaded path of ARIMA time series analysis.

My thanks to Dan Stokols for imbuing me with the importance of robust, theoretical foundations in research. I look back fondly on the hours spent around seminar tables and in Dan's office working on ideas. I don't think I ever left a meeting with Dan without a new stack of books and articles to read.

To my wonderful graduate school friends I offer many thanks for making my years at Irvine such a rich experience. Barbara Easterlin, Betsy "Delightcha" Morgan, and Terri Port are my partners in mischief and adventurous deeds. And to my other buddies at Irvine from years past, members of my office, students in 201, I thank you for being a part of my life at UC Irvine.

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June 1979 - June 1981	Coordinator. Directed and supervised a residential academic program through the integration of formal university courses and extracurricular education activities. Collins Living-Learning Center, Indiana University, Bloomington.
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PUBLICATIONS

Evans, G. W., Palsane, R., & Carrère, S. (1987) A cross-cultural study of the Type A behavior pattern in Indian and United States bus drivers. Journal of Personality and Social Psychology, 52,(5), pp. 1002-1007.

Evans, G. W., Stokols, D., & Carrère, S. (1987) Human adaptation to isolated and confined environments. Technical report prepared for Ames Research Center under NASA Grant 2-387.

Evans, G. W. & Carrère, S. (1988) The effects of the physical environment on human behavior: The workplace as an example. Medecine et Hygiene, 46, pp. 3270-3272.

Evans, G. W., Carrère, S., Johansson, G. (1989) A multivariate perspective on environmental stress. Archives of Complex Environmental Studies, 1,(1), pp. 1-5.

Carrère, S., Evans, G. W., & Stokols, D. Winter over stress: Physiological and psychological adaptation to an Antarctic isolated and confined environment. In A. A. Harrison, Y. A. Clearwater & C. P. McKay (Eds.) From Antarctica to outer space: Life in isolation and confinement. New York: Springer-Verlag. (in press).

PUBLICATIONS (cont.)

Evans, G. W., Carrère, S., & Johansson, G. Inter-relations of physical and psychosocial conditions on health and well being. In O. Manninen (Ed.), Proceedings of the International Symposium on Environmental Stress. Tampare, Finland: University of Tampare Press. (in press).

CONFERENCE PRESENTATIONS

Carrère, S. Human adaptation to chronic stressors: Physiological and psychological patterns of outcomes in an Antarctic setting. First International Congress of Behavioral Medicine. Uppsala, Sweden, 1990.

Carrère, S., Evans, G. W., & Stokols, D. Physiological and psychological patterns of acute and chronic stress during winter isolation in Antarctica. Society of Behavioral Medicine Conference. San Francisco, California, 1989.

Evans, G. W. & Carrère, S. Theoretical models in work environments research. Work Environments and Cardiovascular Disease Conference, National Heart, Lung, and Blood Institute. Irvine, California, 1989.

Evans, G. W., Carrère, S., & Johansson, G. Inter-relations of physical and psychosocial conditions on health and well being. International Symposium on Environmental Stress. Tampare, Finland, 1989.

Carrère, S., Evans, G. W., & Stokols, D. The built environment and human adaptation to an Antarctic isolated and confined environment. NASA-NSF Conference, The Human Experience in Antarctica: Application to Life in Space. Sunnyvale, California, 1987.

Evans, G. W., Palsane, R., & Carrère, S. A cross-cultural study of the Type A behavior pattern in India and United States bus drivers. 93rd annual meeting of the American Psychological Association, Los Angeles, 1985.

Curbow, B., Carrère, S., & Granger, J. Training for social responsibility: Alternatives to traditional graduate curricula. Presented as part of a symposium on Graduate Training and Social Responsibility. 93rd annual meeting of the American Psychological Association, Los Angeles, 1985.

Mullins, L., Carrère, S., & Morgan, S. J. "Sexism and Racism Awareness Training in Institutions," National Women's Studies Conference, Bloomington, Indiana, 1980.

ABSTRACT OF THE DISSERTATION

Physiological and Psychological Patterns of Acute and Chronic Stress During Winter Isolation in Antarctica

by

Sybil Carrère

Doctor of Philosophy in Social Ecology

University of California, Irvine, 1990

Professor Gary W. Evans, Chair

Dissertation: This research employed time series analysis techniques to provide a model of sequential environmental-person transactions in the chronically stressful setting of Antarctica. It examined the dynamic influences of discrete and ambient environmental factors on well being rather than treating the setting as a static, composite variable. As a result, this study extends knowledge about both chronic stress and isolated and confined environments.

Nine men spending the winter at Palmer Station, Antarctica participated in this research. Weekly measures of catecholamines,

cortisol, and blood pressure were taken. The Bipolar Profile of Mood States was used to index psychological well being. The chronic elements of the environment included the length of stay in the setting and weather conditions. Acute factors in the setting were festivities and the arrival of a new station crew.

Subjects habituated to the predictable demands of the isolated and confined setting. Stress outcomes did not increase as a function of the length of stay. Participants did not adapt to the unpredictable, changing weather. As weather conditions worsened depression increased and catecholamine and systolic blood pressure levels decreased. Environmental forces at play in this setting did not operate alone. Acute events such as parties increased levels of catecholamines. During those times of both high winds and parties, the arousing qualities of the parties tempered the weather's depressing impact. The arrival of the new crew was associated with increases in blood pressure.

The dynamic interplay of acute and chronic factors in the Antarctic setting indicates that models of the chronic stress process need to account for not only the static environmental demands of a setting but also those elements of the environment that change.

Chapter One

Isolated and Confined Environments

The isolated and confined environment (ICE) is an area of environmental stress that has received very little attention by United States investigators. These settings are theoretically interesting because they are characteristically low in sensory stimulation, yet confront inhabitants with a combination of physical and social stressors. Natural ICEs are especially interesting because they allow investigators to examine stress issues of broader application in settings which combine the controlled qualities of a laboratory with the realistic qualities of a field situation.

Between the late 1950's and the early 1970's there was a flurry of psychological and medical research conducted on ICEs, such as Antarctic research stations, underwater habitats, and space vehicles. Little psychological research has been conducted on the impact of isolated and confined environments since then. Understanding the physical and psychological components of ICEs is important because many people are exposed to these settings. Naval submarines routinely go on 60 day patrols wherin outside communication is extremely limited. Oil companies employ professional divers who are required to remain in hyperbaric chambers for a month at a time. Research and business require the maintenance of isolated stations in both polar regions which can be isolated for 6 to 9 months at a time. NASA's proposed space station will confine and isolate its inhabitants for extended periods of time as well.

Much of the psychological research conducted in field ICE's has focused on group dynamics and changes in behavior (Oliver, 1979; Radloff & Helmreich, 1968; Earls, 1969; Johnston & Dietlein, 1977). Only a few field studies have examined the relationship between the physical environment and human behavior (Rivolier, 1973; Ogata, 1959; Ito, 1959). This study used inhabitants of a winter Antarctic research station to examine human adaptation to a natural, long-term ICE. It extends the research previously conducted in field ICE settings by measuring weekly physiological and psychological outcomes and incorporating them into a time series model of physical and social moderators of adaptation to the ICE.

This introductory chapter will define what makes an environment isolated and confined, and give an overview of previous ICE research that has been conducted in laboratory and field settings. The review of prior ICE studies will focus on the methodological strengths and limitations of those investigations as well as describing what has been learned about human behavior under these conditions.

Key Elements of an ICE

Isolated and confined environments have both a psychological and a physical side to their make up. Rasmussen (1973) points out that isolation is primarily a psychological concept in that the individual is separated from his or her social network. Isolation involves a reduction in sensory and social input (Zubeck, 1973). Haythorn (1973) suggests that as social organisms, humans' behaviors are largely determined by interpersonal needs. When individuals are separated from their normal social network, abnormal behavior can occur (Suedfeld, 1974). Isolation can sometimes have a physical component when the isolation is imposed by geographical or other physical boundaries. However, it is the psychological response to the reduction in social and sensory stimuli that seems to generalize across situations in which individuals are socially isolated. This occurs regardless of the physical or social variables responsible for the isolation (Rasmussen, 1973; Suedfeld, 1980).

Confinement is a salient physical dimension of ICE settings. In confined environment the mobility of an individual is restricted in some manner, usually because the amount of physical space is limited. The confinement element of an ICE is due, in most cases, to a harsh exterior environment which limits or prohibits activity outside of the built habitat. In the space lab it was the vacuum and extreme temperatures found in outer space that created a harsh exterior. Water pressure, lack of air, and cold temperature limit or prohibit outside activity in underwater habitats like submarines and SEALAB. In Antarctica, the harsh weather conditions, dangerous ice formations, and day/night cycles restrict movement outside buildings.

There are both physical and social aspects of the ICE that can combine to make it stressful to its inhabitants. While the people who live in these environments demonstrate the ability to adapt, there may be long-term costs to the human system of monitoring and coping with the threats that these factors represent (Lazarus & Folkman, 1984; Cohen, et al., 1986; Wohlwill, 1974). These long-term costs may result in subsequent physical and mental ill health (Cohen, et al., 1986). Behavior changes associated with stress have been recorded in ICEs and include: declines in alertness and mental functioning; slumps in motivation; increases in somatic complaints such as sleep disturbances, digestive problems, and symptoms of colds and flu; social withdrawal; self reports of depression and hostility; group splintering and polarizations; feelings of helplessness; and psychotic episodes (Suedfeld, 1974; Rasmussen, 1973; Oliver, 1979; Natani & Shurley, 1974; Edholm & Gunderson, 1973; Weybrew & Noddin, 1979). The physical and social factors which may cause stress in an ICE are reviewed below.

Physical Stressors

Physical sources of stress can include crowding, irregular or unnatural light cycles; changes in pressure; fluctuating and/or extreme temperatures; noise; poor air ventilation; sterile and monotonous surroundings; and the physical threat to life of the exterior environment. Expense and the harsh environment often requires ICE habitats be small, leading to the crowded conditions commonly found in submarines, space vehicles, and some Antarctic research stations. The threat to life is a characteristic feature of the environment that surrounds the ICE. In Antarctica, harsh weather makes inhabitants dependent on imported buildings and supplies. The strict rules that govern staff members' behavior outside of these buildings, and regular, mandatory patrols of the buildings that insure against fire and equipment breakdown, are reflections of the danger associated with the habitat (USARP Personnel Manual, 1983). Temperatures may be extreme in ICE settings. The SEALAB had both the extreme cold of the water surrounding the submerged environment and the high temperature found inside the hull. In other ICEs the extreme temperatures may be external only, as in the case of the space shuttle. Subjects exposed to extremely warm temperatures have experienced both mood and physiological effects (Bell & Greene, 1982). Humidity may also be very high or low depending on how the ICEs built environment interfaces with the external environment and the requirements of the internal environment's air system. Humidity interacts with temperature and may increase thermal stress by reducing the efficiency with which the body maintains its core temperature (Bell & Greene, 1982). Irregular light cycles may disrupt inhabitants' circadian rhythms (Brown and Graeber, 1982). These irregular light cycles can occur because the day and night portions are exceedingly short, as experienced in space flight; or because daylength is brief and nights are long (or vice versa), as in polar settings; or because there is no natural light, as is the case for submarines.

Loud noise levels typically occur in ICEs with engines responsible for propulsion and/or life support systems (e.g., ships, submarines, space vehicles, the SEALAB, and Antarctic stations). There is extensive literature linking noise with increased levels of physiological and psychological stress (Cohen & Weinstein, 1982). Lack of fresh air is a problem with any ICE that is dependent on recycled air. This can lead to feelings of claustrophobia and a loss of control over the environment. Often these settings have a sterile quality due to the lack of personalization or lack of aesthetically pleasing materials. This sterile environment is often a result of the expense of importing these items to the ICE (e.g., Antarctic research stations and orbiting space habitats), and/or the space limitations and functional requirements of the environment (e.g., underwater and space habitats).

Very little research has been conducted on the effects of the physical environment on ICE inhabitants; Rivolier (1974) has conducted the only ICE research on the relationship between weather conditions in Antarctica and psychological and somatic disturbances. He found no relationship between outside temperature and residents' moods, but did find an increase in psychological disturbances and somatic complaints on those days when weather conditions were rated best or worst. Rivolier felt that the meteorological environment has a direct impact on the psychological environment of the ICE.

Studies utilizing laboratory settings to examine the effects of crowding in ICEs have found that territorial behaviors become pronounced in ICEs (Altman & Haythorn, 1967; Taylor, Wheeler & Altman, 1965; Haythorn, 1973). It also has been observed in laboratory settings that privacy reduces stress responses to crowding. In laboratory settings, subjects under ICE conditions have reported more stress as a result of crowding than do control subjects exposed to similar numbers of people in the same amount of room that is not isolated and confined. Haythorn (1973) postulated that the stress experienced in crowded ICEs was due to the inability of ICE inhabitants to escape personal interaction. Crowding has not been specifically studied in natural ICEs. However, Radloff and Helmreich (1968) reported that the outcomes associated with crowded laboratory ICE's were not found under crowded conditions in the SEALAB. Radloff and Helmreich suggested that the laboratory findings did not generalize well to the natural setting because the laboratory did not provide similar intrinsic rewards.

Changes in light periodicity on human circadian rhythms has been studied more extensively in naturalistic ICEs than any other physical environmental factor. These studies have found that changes in day length result in changes in sleeping patterns, body temperature, and mood (Ashina, 1973; Yoshimura, 1973; Simpson, et al., 1973; Lobban, 1973; Ito, 1959; Ogata, 1959; Deryapa, et al., 1982; Topfer, 1980). To date, there are no studies that have determined how changes in light cycles interact with other ICE stressors on human inhabitants.

There has been no other ICE research conducted on the role physical environmental factors may play in causing psychological and physiological stress. What conjectures there are about the part the ICE physical environment may play in causing stress has been inferred from research conducted in other settings. The meaning that these other settings (e.g., dormitories, prisons, hospitals, urban housing) may have for their inhabitants could be very different than the ICE has for its residents. These contextual differences may result in very dissimilar person-environment transactions. Altman (1973) has raised this issue in his call for a person-environment transactional model for ICEs.

Social Stressors

Most of the research that has been conducted on ICEs has focused on social stressors associated with these settings. Although an overview of this literature will be given later in this chapter, so that the methodological strengths and limitations of these studies can be placed into context with the research proposed herein, it is important to introduce the types of social stressors experienced by ICE inhabitants.

The social stressors associated with an ICE include the loneliness associated with being separated from one's normal social network; a reduction in privacy; the necessity of forced interaction with other members of the ICE; dependence on a limited community of individuals for one's social needs with no control over who may be included in that group; and having little or no ability to help loved ones with problems that may arise. These aspects of an ICE can lead to social withdrawal, feelings of helplessness, aggressive or depressed mood states, psychotic episodes, and changes in physiological levels of arousal (Suedfeld, 1974; Rasmussen, 1973; Oliver, 1979; Natani & Shurley, 1974; Edholm & Gunderson, 1973;

Weybrew & Noddin, 1979).

Positive Components of ICEs

Very little attention has been paid to the more positive aspects of the ICE. Suedfeld (1980) believes that environments which have reduced stimulation may have positive attributes if those settings are considered attractive by their inhabitants. He feels that cultural beliefs play a large role in whether reduced environmental stimuli is considered a positive aspect of a setting. Natani and Shurley (1974) feel that little attention has been given to the good components of the ICEs because negative affect and feelings were more readily identifiable and less elusive than positive affect and feelings. Oliver's 1979 Antarctic study followed up on anecdotal reports of positive regard for the ICE, increased self awareness, and personal growth after dwelling in ICEs. She found that scores on the Minnesota Multiphasic Personality Inventory's (MMPI) subscales for paranoia and schizophrenic qualities decreased over the course of the winter, while scores on scales measuring self actualization and self acceptance increased. Ninety-three percent of the 39 subjects in her study reported a very positive experience. Other studies which questioned individuals about why they volunteer to spend time in an ICE find that there are a number of ICE qualities that are attractive including:

1) receiving good pay;

2) eating good food;

3) experiencing an exciting environment that few have the

opportunity to visit;

4) getting relief from societal or familial demands, conflicts, and responsibilities;

5) belonging to a special group of individuals who have the "right stuff" to be able to go to such a place;

6) self-selecting to belong to a social group which shares common values;

7) having work schedules which provide more free time (in some ICEs);

8) living in an environment which moves at a slower pace without all the pressures found in most urban settings;

9) having free time to focus on self growth and special projects;

10) belonging to a community which may provide stronger social bonds and community-spirited activities than are typically found in the United States

(Natani & Shurley,1974; Oliver, 1977; Edholm & Gunderson, 1974; Rasmussen, 1973; Weybrew & Noddin, 1979; Harrison & Connors, 1984).

Overview of the Methodological Approaches Taken in Previous ICE Research

The major problem with previous research conducted on ICEs has been the methodological limitations of the studies. In the following section of the introduction, the different approaches to ICE research will be discussed and their strengths and limitations described. One of the assertions of this chapter is that some of the findings of prior studies on ICEs may be open to contention because of the methodological restrictions and weaknesses of the investigations.

Laboratory Studies

Research on ICEs has taken two general forms, those studies done in laboratory settings, and those studies conducted in field situations. Laboratory studies have provided useful information about crowding effects, territoriality, group cohesion and conflict, sensory deprivation, and disruption of circadian rhythms (Taylor, Wheeler, & Altman, 1968; Altman, 1973; Haythorn, 1973; Zubeck, 1973; Brown & Graeber, 1982). Radloff and Helmreich (1968) have criticized ICE simulation studies because these laboratory results have not generalized well to natural ICE settings. There are a number of reasons why this may occur. Laboratory studies which are relatively brief in duration do not allow the gradual onset of stress that occurs in natural ICE's. Laboratory settings also do not provide the rewards associated with the exotic qualities of the natural ICE (Radloff & Helmreich, 1968). In addition, there are ethical limitations in inducing the level of stress in laboratory settings that might be found in the field ICE. It is also difficult to maintain such heightened levels of stress, necessary to model the ICE, in the lab. Finally, Radloff and Helmreich (1968) point out that laboratory studies use subjects who are more likely to volunteer for short-term experiments than individuals who are likely to volunteer for long-term natural ICEs.

Field Research

Anecdotal Reports

ICE research conducted in the field has taken three forms: anecdotal accounts; indirect, quantitative observations; and direct, quantitative observations. The majority of the studies have been anecdotal accounts drawn from diaries, logs, or evaluations by peers and supervisors. The biomedical research from the Skylab missions focused primarily on changes in bodily processes as a function of weightlessness. The only psychological data reported came from subjective overviews by the astronauts (Johnston & Dietlein, 1977). Research on environmental stress experienced by submariners has primarily drawn on officers' or ship physicians' personal observations (Earls, 1969; Kinsey, 1959). Antarctic research arose out of this tradition, drawing on the journals of the explorers and many of the early winter-over crews (Law, 1960; Byrd, 1938; Siple, 1959; Wilson, 1966; Cherry-Garrard, 1922). The information drawn from these anecdotal accounts is most useful for developing a conceptual picture of the ICE experience. Themes and patterns can be derived for the construction of hypotheses for more quantitative studies. The weakness of such reports is their subjective perspective and unquantified conclusions.

Indirect, Quantitative Research

Indirect, quantitative research refers to studies which have been conducted by scientists who are not present in the field during their subjects' exposure to the ICE. The measures they use are quantitative in that they are measuring specific variables and testing hypotheses. Studies that use indirect quantitative observations base their findings on interviews of ICE inhabitants; questionnaires filled out before and after the experience, but rarely during the experience; medical and mental health reports; site visits; and organizational records (Nelson, 1973). Weybrew and Noddin (1979) examined the mental health records of submariners relieved from duty to determine environmental and health factors contributing to personnel duty disqualification. They found that one of the primary causes for duty disqualification was maladaptive interpersonal relationships.

Most of the research conducted in Antarctica on human adaptation has been conducted in an indirect manner. These studies have focused primarily on uncovering personality factors which contribute to successful adaptation to the ICE, with the intent of developing selection criteria for ICE personnel (Gunderson, 1973a; Gunderson 1973b; Gunderson, 1974; Smith & Jones, 1962; Nardini et al., 1962; Taylor, 1973; Crocq, Rivolier, & Cazas, 1973; McGuire & Tolchin, 1961). These investigators found that emotional stability, high task motivation, and social compatibility were the most important personality characteristics in predicting successful adaptation to the Antarctic ICE.

One of the strengths of the quantitative indirect observation methodology is the melding of anecdotal accounts drawn from interviews, and more quantitative measures. This allows one to develop hypotheses which can be tested and places quantitative data in context. However, important information about the ICE experience may be missed because quantitative data is only collected before, after, and (at best) several times during the ICE tenure. Both the quantitative and qualitative data tends to be retrospective since the questionnaires and interviews ask the subject to recall experiences. This may result in selective and incomplete information being collected. An additional problem occurs when the scientists administering the study are perceived as outsiders who have not experienced the ICE and thus don't belong to the "club," or are perceived as having some influence over the subjects' future job opportunities. Under these situations the questionnaires and interviews may contain information that is distorted and incomplete. A simple example of this problem is the alcohol consumption questionnaire that the U.S. Navy administers as part of its screening process for Antarctic personnel. Winter-over personnel from the year this study was conducted, as well as other years, reported lower levels of alcohol than they actually consume because they didn't want to be excluded from the Antarctic program. This kind of research may also miss the crucial dynamics taking place because the investigators either do not have first hand ICE experience, or because they are not present to adjust the instruments to fit what is taking place in the ICE.

Direct, Quantitative Research

This category of research refers to quantitative studies which have been conducted by investigators directly observing subjects under ICE conditions. Quantitative, direct observational studies of ICEs have been infrequent. Radloff and Helmreich (1968) conducted one of the most complete studies of this nature with the SEALAB underwater habitat. Using TV cameras, microphones and a battery of paper and pencil measures, these investigators were able to examine in detail, individual and group responses to a short-term, crowded underwater ICE. They observed that overall adjustment to the underwater habitat was good. They found strong cohesiveness among the aquanaut teams and very little evidence of interpersonal problems. They also concluded that the personality variables predicting successful adaptation to Antarctic ICEs (described above) were not significant predictors of who adjusted best to the SEALAB. In addition, Radloff and Helmreich found increased dependency on team leaders under ICE conditions. A major methodological limitation of this study was that it only looked at a short-term exposure to an ICE. It is possible that interpersonal friction and individual stress may have occurred if the aquanauts remained in the SEALAB for a greater duration.

Direct, quantitative research on the psychological adaptation to Antarctic ICEs has been very limited. Smith (1966) evaluated human adaptation and group interactions on a seven person transverse of the Antarctic Plateau during a summer expedition. He observed that group dynamics were structured around job responsibilities. Members of Smith's expedition also reported they would prefer to go on future ICE ventures with individuals in the group with whom they had had the least interactions.

An international expedition of researchers traveling in Antarctica during the summer season of 1980-81 kept records of human performance, perceived stress, and coping skills and compared those measures with control groups (Defayolle, et al., 1985; McCormick, et al., 1985). They found no differences on performance measures when compared with pre and post Antarctic measurements (Defayolle, et al., 1985). Self-reports of stress were collected for both the Antarctic expedition members and a New Zealand control group. No differences were found between the New Zealand and Antarctic groups. Coping styles proved to be a good predictor of who reported higher levels of stress. Those subjects who were prone to repressing their personal needs as a style of coping reported less stress than did subjects who tended to accentuate the importance of personal comfort (McCormick, et al., 1985).

There have only been four psychological winter-over studies in Antarctica using direct, quantitative measures. Palmai (1963) conducted research which is probably the most comprehensive of this group. Using subjects at an Australian station, he took weekly audio recordings of group discussions for an hour after dinner; quarterly measures of group and individual social preferences; and personal reactions and symptoms reported to the station medical officer. These data were evaluated for group dynamics and adaptation to the ICE. He found that individuals became more responsible about job performance as the year went on, but were less community-minded. Morale was found to be lowest in the third quarter of the year with increased levels of aggression and somatic complaints.

Natani and Shurley (1974) asked winter-overs at South Pole station to record their leisure activity for a week every two months. Natani recorded station members' activities on a daily basis. Natani and Shurley found that there were no major changes in activities over the winter and interpreted these results to mean that no changes in adaptation took place over the course of the winter.

Oliver (1979) looked at psychological adjustment to the Antarctic ICE by asking winter-over members of McMurdo Station to fill out psychological adjustment scales three times during the winter months. She found a general increase in self awareness and mental health over the course of the winter.

Research by McGuire and Tolchin (1961) evaluated group and individual adaptation at South Pole using paper and pencil measures, general observations, supervisor evaluations, and medical records. They reported that while overall group dynamics were positive, that some individuals were perceived by themselves and other members of the station as not being well accepted by the crew. The variables which did the best job of predicting who would fall into this "outsider" category were age (younger) and ranked ratings for successful adaptation by psychiatrists using pre-ICE interview transcripts.

A major drawback in conducting direct, quantitative research in ICE settings is that the members of the habitat object to being the subjects of such ongoing research. This problem has been cited by Taylor and his associates (1985) and Rivolier (1973) as interfering with research protocol or causing studies to be terminated. There is a feeling that one is being personally evaluated and placed under psychiatric scrutiny. This leaves individuals thinking that they can not relax and be themselves. In addition, the investigator can influence the outcomes of the research through his or her interactions with other members of the research setting.

The advantages of conducting research that is quantitative and directed by an investigator in residence are numerous. These advantages include recording physiological, psychological and environmental variables as they occur rather than retrospectively, and the opportunity to make anecdotal observations that can provide context for the quantitative data and provide ideas for complementary research. The ability to adjust or add measures to fit the dynamics of the specific ICE under examination is difficult to do unless the investigator is present in the setting. Being a member of an ICE community under study also allows the investigator to compare self-reports of behavior with observed behavior. Finally, because the investigator is a member of the community and shares its experiences, community involvement and commitment to the study is enhanced in quantitative, participant studies.

The direct, quantitative ICE studies that were reviewed above have been important because they have provided a more complete, objective picture of group and individual adaptation than has been available before. Studies which look at the physical environment's effect on behaviors are still missing. In the few studies which have examined the effects of the physical environment on stress outcomes, the investigators have only looked at one or two variables rather than building a model of how these environmental factors impinge on the ICE inhabitants over time. The majority of previous research has measured behavior under the settings' general conditions but has not examined how changes in the environment influence behavior. In addition, the measures in these studies have been taken infrequently increasing the likelihood of missing important behavior changes. The SEALAB study took continuous measures but it was a short-term ICE and may not have allowed long-term stresses associated with ICEs to take place. Moreover, this study did not examine environmental variables, focusing instead on social dynamics and individual adjustment to the ICE.

None of the studies reviewed above have examined both physiological and psychological outcomes of stress. Most models of stress hypothesize that the stress response is both physiological and psychological in character (Cannon, 1932; Selye, 1956). Research which incorporates measurement of both psychological and physiological stress indicators will provide a more robust picture of the transactions between the individual and his or her environment. Finally, none of these research projects attempted to build a model of what takes place between residents of an ICE and their physical and social environment. Both Altman (1973) and Sells (1973) suggest that it is important to develop models of adaptation to ICEs so that research findings can be generalized across settings and so that a more comprehensive picture can be developed of how factors interact within an ICE.

Statement of Research Intent

The present study is unique because it attempts to address some of the shortcomings of the research described above. The present study looks at not only individuals' reports of their mood but also at physiological arousal using measures of urinary catecholamines and blood pressure. In contrast to previous long-term studies done in the field, this study records information on a weekly basis over the course of the austral winter to provide frequent quantitative measures of the stress experienced by ICE inhabitants. These indices of stress will be compared with physical and social changes in the ICE to develop a sequential model of transactions between people and the environment in an Antarctic ICE.

Chapter Two

Theoretical Perspectives on Chronic Stress

> "Adaptability is found throughout life and is perhaps the one attribute that distinguishes most clearly the world of life from the world of inanimate matter. Living organisms never submit passively to the impact of the environmental forces; however primitive they may be, all of them attempt to respond adaptively to these forces, each in its own manner."
>
> — R. Dubos,
> Man Adapting, 1965.

> "More significant is the fact that the vast majority of the thousands of prisoners who died at Buchenwald each year died soon...After one had learned how to live in the camps, the chances for survival increased greatly."
>
> B. Bettelheim
> The Informed Heart:
> Autonomy in a Mass Age, 1960.

Humankind has demonstrated the ability to adapt to extreme environmental settings whether harsh physical conditions such as the severe cold of the polar regions, or extreme social conditions such as the concentration camps of Nazi Germany. The thesis of this chapter is that stress is a dynamic, ongoing process. Models of chronic stress, and research that treat chronic stress as a static environmental demand on the organism miss a critical component of the stress process. In any setting, what an individual experiences is not a static demand from the environment. Physical and social forces in any environment are constantly changing. In addition, as an individual becomes familiar with the characteristics of a stressor, its threatening qualities often decrease. The fluctuating demands of the environment on the person influence physiological arousal and psychological mood. The ability of the individual to adapt to changing environmental demands is believed to have implications for health outcomes.

This chapter will develop the argument that the chronic stress process is dynamic in nature. The role of homeostasis in the stress process will be explored both in terms of its contributions to theories of stress and in describing the part homeostasis may play in the chronic stress process. I begin the chapter by focusing on the early theories of stress and homeostasis mechanisms. The chapter then turns to the topic of chronic stress. Three models of chronic stress that currently exist in the literature will briefly be discussed. Finally, the chapter examines the paradigm of the chronic stress process as a dynamic, adaptational process.

Homeostasis and Stress

Stress is most often treated as a transaction that takes place between an organism and stimuli it perceives to be threatening or harmful (Lazarus, 1966). Stress occurs when the resources of the organism have been exceeded by the demands of the environment. Both the environment and the capability of the individual to respond to the stimulus in a masterful fashion have a strong influence on human health and well being (Lazarus & Folkman, 1984; Baum, *et al.*, 1982; Evans & Cohen, 1987). Too much stress is believed to lead to illness.[1]

Much of the early work on stress focused on physiological mechanisms underlying the responses of organisms to stressful stimuli. Physiologists conducting this research were interested in the homeostatic mechanisms of the body, and the ability of the body to self-regulate and maintain its internal balance over time in the presence of harmful, threatening, or challenging agents (Bernard, 1966; Cannon, 1932; Selye, 1956). Claude Bernard (1966) emphasized that life was dependent on the ability of the body to maintain its internal milieu in a relatively constant state. Cannon's (1932) research found that warm-blooded organisms are able to resist external and internal stressors such as extreme temperature, loss of oxygen to the cells, and dehydration through internal control mechanisms which increased activation of the sympathetic nervous system (SNS) and secretions of the associated adrenal medulla. He also thought that the sympathetic-adrenal-medullary system (SAM) provided a natural defense against external agents that might seek to kill the organism. The increased level of stimulation by the SAM axis could result in increased internal resources to help the organism struggle for survival, whether that struggle meant fighting or fleeing. Cannon theorized that the physiological arousal response induced by the SAM axis gave the organism an adaptive advantage by allowing it to respond more quickly to danger. Homeostasis, or physiological equilibrium, was still at the heart of Cannon's argument. An organism might respond to a stressor with a temporary surge of SAM arousal but unless it could rapidly return to original homeostasis levels of physiological arousal, critical damage could be done to the organism. This damage could even result in death.

Selye's research provided information about how stressors could permanently disrupt the body's physiological equilibrium. Selye (1956) developed his model of stress as a product of his research on the hypothalamic-pituitary-adrenal cortical axis (HPAC) of the body. He found that injections of foreign tissues and chemicals into rats produced similar patterns of outcomes. Selye theorized that the body would go through the same sequence of responses regardless of the nature of the stressor. He called this sequence of the responses by the organism the general adaptation syndrome. Alarm, the first stage of the response, is initiated when the organism detects the stressful agent. During this phase the body activates its internal resources in order to meet the increased demands made by the stressor. In the alarm stage the anterior pituitary gland increases its secretion of adrenocorticotropic hormone (ACTH), which in turns triggers an increase in the secretion of adrenal cortex hormones. The cardiovascular and respiratory systems also increase their level of operation during this period. In the second phase of the general adaptation syndrome, the resistance stage, the body maintains the increased arousal of its various internal systems to cope with the demands of the stressor. The third stage, exhaustion, occurs if the stressor is too severe, or if the duration of the stressor depletes the resources of the organism. During the exhaustion stage, the inability of the organism to resist, or adapt to the stressor can lead to physiological damage of organs and even death. Again, the ability of the body to return to homeostatic norms is the major determinant in Selye's model of stress as to whether there will be negative health outcomes associated with the stressor.

More recent research (Mason, 1975; Lacey, 1967; Frankenhaeuser, 1975) has provided evidence that the route that the stress process takes is dependent on qualities of the stressor and psychological characteristics of the organism.

Summary

Homeostasis, or physiological equilibrium, is an integral factor in maintaining the health of the organism. Homeostasis in an organism is maintained by feedback mechanisms that provide information to the body when an physiological parameter is too low or too great. For example, when blood pressure levels get too high, baroreceptors in the artery walls of the thoracic and neck respond by sending a signal to the brain which in turn dampens SNS activation levels and increases the activation level of the parasympathetic nervous system (PNS).

The research of Cannon and Selye demonstrated the importance of physiological homeostasis. Cannon (1932) believed that a major adaptive response of the body was to maintain a steady state or homeostasis in the face of shifts in external and internal environments. If a stressor caused a large enough disruption of the body's steady state Cannon found that the organism could not recover, and this would lead to illness or death. Selye (1956) though that the exhaustion stage of the general adaptation syndrome came about through repeated or an extended drain on the body's emergency resources. When exhaustion occurred irreparable damage could be done to the body, leading to disease or death.

Chronic Stress

How does an organism adapt to stressors that remain present in an environment over an extended period of time? Diseases such as cardiovascular disease (CVD) and various cancers are believed to develop over long periods of time. The temporal qualities of the stress process are thought to be linked to negative health outcomes such as CVD and cancer. For example, atherosclerosis is a potential outcome of essential hypertension (West, 1985) and is a major component of CVD (Krantz & Manuck, 1984). Atherosclerosis develops over the life span and is believed to build up to pathogenic proportions through either or both hemodynamic stresses on arterial walls and junctures, or through toxic effects of neurochemical excesses. Both of these processes result in excessive buildup of arterial plaque leading to CVD (Clarkson, et al., 1986). Excessive stress is thought to accelerate the build up of arterial plaque (cf. Matthews, et al., 1986).

Chronic stress has often been addressed as a static, unchanging environmental demand on the organism. Chronically stressful settings such as work environments with high job strain, very noisy home and school settings, isolated and confined environments, or even concentration camps have typically been treated in the stress literature on the basis of their accumulative impact on individuals. These settings are not usually examined in terms of their changing nature over time. It is important to consider the role of change in environmental demands. Objective changes in acute and chronic environmental demands contribute to the dynamic quality of the chronic stress process. While health outcomes associated with chronic stress may be due in part to the cumulative impact of stressors over time, health outcomes associated with chronic stress may also be a result of the <u>change</u> in the levels and characteristics of environmental demands across time. To put it differently, rather than focusing exclusively on the between group variance among situations of varying, overall environmental demands, I call attention to the within group variance, caused by the dynamic, ever fluctuating ebb and flow of demands within chronically, stressful settings. Changes in an environmental setting may require increased monitoring by an individual in order to appraise the nature of the change and choose an appropriate coping strategy.

Another dimension of the chronic stress process is adaptation. Individuals have adaptational skills that allow them to reduce the threat of unchanging chronic stimuli and subsequently experience the chronic stimuli as part of what is considered a normative setting. These adaptational processes may serve as a form of homeostatic control that prevents individuals from exhausting their internal physiological and psychological resources.

In the following discussion I will briefly review three models of chronic stress that come from the stress literature: the reactivity model of chronic stress, the cumulative costs of coping model of chronic stress, and the habituation/adaptation model of chronic stress. I will then propose a dynamics model of chronic stress. This dynamics model of chronic stress draws on principles and research outcomes of each of the first three models of chronic stress. The dynamics model of chronic stress goes beyond these three models of chronic stress by 1) considering the role of change in the setting itself; and 2) by proposing a mechanism of physiological and psychological homeostasis in response to ongoing stimuli.

Models of Chronic Stress

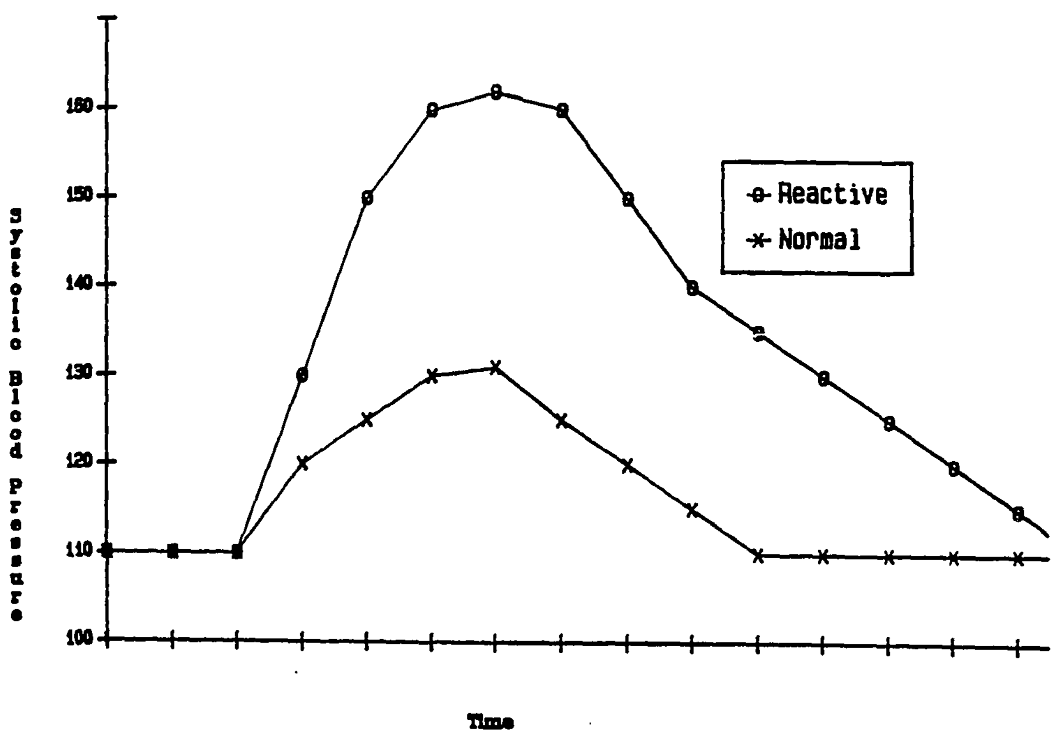
There are three principal models of chronic stress that have emerged from the chronic stress research on the neuroendocrine and cardiovascular systems. These three models are: the reactivity model of chronic stress, the cumulative costs of coping model of chronic stress, and the habituation/adaptation model of chronic stress. Each of these models incorporates homeostatic mechanisms. Each model recognizes that the body has a level of physiological equilibrium that can be considered a baseline level. In response to chronic stressors two of the models, the cumulative costs of coping and the reactivity model, describe mechanisms whereby the body's ability to self regulate its arousal levels is damaged. In these models, the damage to the mechanisms of homeostatic self regulation are hypothesized to lead to disease outcomes. The third model, habituation/adaptation model proposes that organisms are able to adapt/habituate to a stressor over time.

Reactivity Model of Chronic Stress

The reactivity model of chronic stress asserts that certain individuals may be at increased risk of cardiovascular diseases such as hypertension or coronary heart disease (CHD) because of a characteristic manner of responding to environmental stimuli (Matthews, 1986). These individuals respond to environmental stressors, particularly those of a behavioral nature, with an exaggerated physiological response in comparison with control groups (Manuck & Krantz, 1986). Baselines for these hyperresponsive individuals and control group members are similar, but the physiological responses of the reactive group to stimuli are much greater (see figure 2.1). Members of both the reactive group and the control group return to baseline physiological arousal levels after the termination of a stressor. Whether there are differences in the length of time it takes to return to baseline in reactive individuals versus control group individuals has not been a focus of this body of research (Matthews, 1986).[2]

The reactivity model of stress hypothesizes that chronic stress outcomes, such as hypertension and CHD are due to a chronic, exaggerated pattern of physiological responses (Manuck & Krantz, 1986). The exaggerated physiological response subsides after the termination of each stressor, however the response pattern itself is chronic. Obrist (Obrist, 1981) applied this model to the etiology of hypertension. He suggested that some forms of hypertension are a result of the impact of chronic stress on the regulatory component of

Figure 2.1 A Comparison of Normative and Reactive Systolic Blood Pressure Response to a Stressor



will briefly review that theory.

Lazarus and his colleagues believe that there are two stages to the stress process. The first is primary evaluation of the stimulus which takes into account both personal factors (goals blocked, skills for mastery, dispositional components) and situational factors (magnitude, duration, ambiguity, imminence of harm). The stimuli is appraised and if it represents harm, a threat, or a challenge then the individual's coping repertoire is reviewed and an appropriate coping strategy is used to meet the demands of the stressor. The coping style used can either be problem focused and active in nature, or palliative and focused on changing the emotions associated with the stressor or the meaning of the stressor. Lazarus considers this to be an ongoing process in which individuals continually appraise their environment and readjust their coping strategies to meet its demands. The psychological perspective on the stress process suggests that the same situation can have different meanings for different individuals. Different coping strategies can be utilized by different individuals even when the situation may have the same meaning applied to it.

Lazarus and Folkman (1984) believe that chronic stress is the accumulation of acute stress events that results in a habitual pattern of appraisal and coping. This habitual manner of responding to the environment leads to problems. They suggest that coping and appraisal processes can have adaptational outcomes in the areas of work and social living, self esteem or morale, and somatic health.

One's long term ability to function effectively in work and social settings is the result of an accumulation of short term encounters with events requiring appraisal and coping. Success is determined by appraisal and coping effectiveness. The effectiveness of appraisal and coping results in the minimization of outcome costs to the organism. Morale is tied to how people feel about themselves. The morale outcome for each event depends on the sum total of previous experiences. The long term outcomes are a result of patterns of how one judges one's success in appraising and coping effectively with the environment. Somatic outcomes in the short run are the physiological changes that take place in response to individual events. Long term outcomes such as cancer and CVD can come about through patterns of coping styles including: behaviors which directly put an individual at risk (e.g. cigarette smoking); behaviors such as denial or avoidance which can keep an individual from taking a more effective approach in mastering a stressor; or coping strategies that result in physiological outcomes causing excessive wear and tear on the body.

The reactivity physiology model of chronic stress is compatible with Lazarus and Folkman's (1984) conceptualization of chronic stress. Chronic stress outcomes are due to a behavioral pattern of coping with stressors. This problematic coping behavior is what is theorized to lead to the breakdowns in the body's homeostasis mechanisms, such as the baroreceptors. These breakdowns in homeostatic mechanisms, in turn, lead to increased wear and tear on the body, or breakdowns in the body's defense mechanisms. These deteriorations of the organism are what would lead to an increased risk for disease. When this model is applied to the Type A behavior pattern or theories that suggest that hostile coping strategies underlie hyperreactive responses to stressors (Chesney & Rosenman, 1985), it is conjectured that coping strategies chosen by an individual and over generalized to inappropriate settings could result in alterations in physiological arousal control mechanisms, and exaggerate subsequent responses to stressors. These potentiated responses could hasten the development of atherosclerosis or hypertension.

A number of criticisms have been raised about the reactive model of stress. These criticisms revolve around the paucity of studies done using chronic stressors; the lack of longitudinal studies on reactivity; and a lack of focus on environmental challenges that may cause reactive responses in all populations. Most of the research which tests the paradigm that a chronic pattern of reactive responses to stressors leads to negative health outcomes is based on research measuring physiological responses to discrete, acute stimuli. There has been virtually no research that examines what takes place when these hyperresponsive individuals are exposed to a continuous, chronic stressor. There has been some research on the effects of work environments on Type A individuals. The results of these studies have been mixed. Frankenhaeuser and her associates (1989) reported no significant differences between Type A's and Type B's in response to work stress over a 12 hour period covering time at work and at home in the evening after work. Evans and his associates (1987) found that a United States sample of Type A bus drivers experienced an increase in diastolic blood pressure at work when compared with baseline levels. Type B bus drivers in this United States sample had a reduction in diastolic blood pressure on the job. However Type A bus drivers did not differ from Type B bus drivers on job measures of systolic blood pressure or urinary catecholamine measures. While a day at work may not be considered a chronic stressor, these two studies are representative of the few studies that examine the responses of individuals believed to be hyperreactive in response to more chronic types of environmental stressors. Matthews (1986) has raised the point that little is known about the response of reactive individuals to chronic stressors. Research which focuses on the response of reactive individuals under chronically stressful situations needs to address the question of whether reactive responses observed under acute conditions generalize to chronically stressful situations.

Research is needed that examines reactivity and chronic stress processes associated with disease outcomes. There have been few longitudinal studies which have traced the causal link between reactive responses and disease outcomes. Epidemiological studies such as the Framingham study (as reported in Haynes, et al., 1987) and the Western Collaborative study (1975) have provided evidence that Type A individuals are more likely than Type B's to develop

CHD. However the mechanisms underlying this relationship have not been demonstrated. Cross sectional studies have demonstrated an association between personality types that may be hyperresponsive to behavioral challenges and the presence of extensive coronary atherosclerosis (Dembroski, et al., 1985; Williams, et al., 1980). Again, the causal relationships underlying this hyperreactive response pattern, chronic stress, and health outcomes has not been shown in these cross sectional studies. Investigators using epidemiological and cross sectional research designs have demonstrated that variables associated with hyperresponsive are associated with disease outcomes. However the chronic stress processes that lead to these health outcomes have not been examined using longitudinal research designs.

Finally, research associated with the reactivity model has focused primarily on characteristics of individuals that may be predictive of hyperresponsive physiological arousal in reaction to stressors. There is evidence that suggests that there are environmental conditions that cause exaggerated physiological arousal responses (Karasek, et al., 1982). Individual differences in physiological responses has been treated as a separate topic from environmental conditions that may result in high physiological arousal responses. There has been some discussion of environmental conditions that could lead to the development of behavioral coping repertoires that result in exaggerated physiological responses (Matthews, 1986). It may be that environmental conditions that elicit the same appraisal and coping responses making up the core of the behavioral coping repertoires observed in reactive individuals (e.g. Type A, hostility) result in similar hyperresponsive physiological responses associated with cardiovascular disease outcomes.

Cumulative Costs of Coping with Chronic Stressors Model

Another body of research on chronic stress suggests that responses to ongoing stressors may result in a continuous effort by the body to meet high environmental demands. According to the cumulative costs of coping model, the continuous environmental demand results in a gradual and progressive upward shift in the basal homeostatic level of arousal in the body. Under this scenario, exposure to a chronic stressor would gradually elevate the body's basal physiological level of homeostasis. In addition, the level of physiological arousal that would trigger feedback mechanisms to correct for over arousal by the organism would also increase over time. This model is distinct from the reactivity model of stress in that 1) the homeostasis level of physiological arousal increases over time; and 2) there is a concommitant change in the threshold of physiological arousal necessary to trigger feedback mechanisms to reduce physiological over arousal. The reactivity model of stress states that homeostasis levels of physiological arousal will remain constant but the level at which feedback mechanisms correct for over arousal will be reset at a much higher than normal level.

This cumulative costs model has been applied by Julius and his associates (1986) to the etiology of chronic hypertension. They propose that chronic physiological stress alters the homeostasis of blood pressure in a progressively upward fashion. Julius and his associates (1986) suggest that the physiological mechanisms underlying this process might be a physiological decrease in organ response due to the chronic sympathetic stimulation. The pathway they propose is chronic sympathetic stimulation resulting in the down regulation of adrenergic receptors in the heart leading to decreases in cardiac output. Julius and his associates speculate that this change in cardiac output could lead to subsequent changes in the myocardium structure. The blood vessel walls in turn would increase in thickness resulting in an increase in peripheral resistance. These changes in the heart and blood vessels would result in heightened blood pressure. These structural changes would make it increasingly difficult for the body to override them and lower blood pressure.

Jennings (1983) applies the potential role of the cumulative costs of coping model to coronary heart disease. Based on previous work by John and Beatrice Lacey (cf. Lacey, 1967) he suggests that the chronic allocation of attention to stressors can result in an ongoing or repeated pattern of physiological responses, including elevations in catecholamines, blood pressure, and heat rate, that cause wear and tear on the vascular system and lead to disease.

Cohen and his associates (Cohen, 1978; Cohen, et al., 1986) have developed a psychological model of the cumulative cost of coping.

This model focuses on the role of psychological mediation in the stress process. Cohen's model grew out of the information load model (Poulton, 1977).

The information load model proposes that people only have a limited ability to process information. Overload occurs when environmental demands for information processing are greater than the individual's ability to process that input. Stressors and the subsequent stress response are a result of an overload of information which taxes the body psychologically and physiologically. Over time this can lead to coping strategies which have a cost to the organism. Milgram (1970) suggests that the urban personality of reduced interactions and negative affect may be a cost of information overload. The high level of environmental stimuli present in an urban setting may cause information overload. This input overload may result in both the filtering out of those stimuli that are less important, and taking active steps to limit stimulus input through strategies such as reducing social interactions.

Cohen and his associates updated this model with the cumulative costs of coping model of stress. They introduced the idea that over time exposure to a stressor will result in cognitive fatigue and subsequent shrinking of information processing capacity. Negative responses to a stimulus may increase over time because of the shrinkage of information processing capacity as a result of accumulative cognitive fatigue. These fatigue effects will persist and are manifested in after effects such as physiological arousal, decrements in mood, and reduced task performance. This model indicates that there are costs of coping or accommodating to the demands of stressors regardless of whether those efforts are successful.

Cohen and his associates (1986) believe that the outcomes of the stress process are due more to the costs of coping than to the demands of the stressor itself. Both successful (e.g., tuning out background noise) and unsuccessful coping efforts can have negative outcomes. When coping strategies fail decrements can occur in physiological, behavioral and emotional outcomes. Successful coping can lead to cumulative fatigue which in turn leads to physiological and task decrements, and increases in negative emotions. Evans and Cohen (1987) also suggest that the effort required to cope may reduce the ability of the organism to successfully respond to additional or subsequent stressors.

There is some chronic stress research which supports the physiological and psychological models of the cumulative costs of coping. In a review of the nonauditory effects of noise, Cohen and Weinstein (1982) suggest that there is evidence that links exposure to noise in an industrial setting for over three years with increased cardiac morbidity. Frankenhaeuser's research team has found that chronic exposure to stressors can result in continued elevations of epinephrine if subjective arousal continues (Frankenhaeuser, 1975). Fleming and his associates (1984) found that individuals living near Three Mile Island had higher levels of catecholamines and blood pressure, when compared with control groups, more than a year after the accident. The presence of the nuclear reactor, and the uncertainty of possible cancer outcomes are believed to have perpetuated the duration of stress.

Animal studies reviewed by Scheiderman (1983) have shown that repeated, chronic stressors result in elevated levels of cortisol initially which taper off but still remain elevated when compared with baseline levels. Scheiderman also reports that with chronic physical or emotional stress the elevation in corticosteroids may augment the toxic effects of the catecholamines.

There are some methodological limitations associated with these studies of chronic stress. Many of the studies of industrial noise reviewed by Cohen and Weinstein (1982), as they note, are cross sectional research designs and do not follow subjects over time. Other studies, such as the Three Mile Island research, have taken several measures of chronic stress outcomes over time. However, because of costs or logistics, these studies have not been able to take frequent measures of stress outcomes. By not taking measures of stress weekly or even monthly, most dynamic transactions between the chronically demanding environment and the organism may be missed. When chronic stress has been more closely observed, such as Folkman and Lazarus' (1980) research on coping with daily hassles and other stressors in a community setting, physiological outcome measures have not been used. In the Folkman and Lazarus study, 100 participants were interviewed 7 times at one month intervals to determine what stressful events had taken place during the previous month and what coping strategies these individuals had utilized to meet the demands of these stressors. Folkman and Lazurus' study allowed the examination of the dynamic psychological processes reported by the participants in the study, but did not permit the study of any dynamic physiological transactions between the participants and the environment.

Mechanic's (1962) research on the chronic stress experienced by graduate students studying for qualifying exams utilized weekly interviews of the students to look at chronic stress processes. He also interviewed faculty in the department and family members of the students to develop a social, contextual picture of the stress the students experienced. Mechanic discussed the importance of time sequences in understanding chronic stress, and yet he did not analyze the data using time series or sequential analysis techniques. He described the interaction of the stress due to the qualifying exams with the pressures due to the social environment of the department and home. However, his analysis is descriptive in nature and does not demonstrate in a quantitative fashion the manner in which these variables interacted.

The second methodological problem with research outcomes associated with this model, and a common problem in most studies of stress, is that the separation between what constitutes an acute stressor is not clearly delineated from what defines a chronic stressor. This becomes more poignant when one discovers that what is operationalized as an acute stressor in one study is operationalized by a different set of investigators as chronic. Yet in both studies distinctions have been made between the consequences of acute and chronic stressors (cf. Ader, 1981; Sklar & Anisman, 1981). The length of time that an organism is exposed to a stressor can influence the nature of the coping strategies used to meet the demands of the stressor.

The cumulative cost of coping model indicates that there can be detrimental outcomes of coping with stressors in situations when either the outcomes of that effort are successful or unsuccessful. It suggests that successful active coping efforts may cause fatigue, have side effects, and result in overgeneralizations of coping behaviors to inappropriate settings. Unsuccessful coping efforts may have all of these outcomes as well as learned helplessness and passivity in the face of subsequent stressors (Cohen, et al., 1986). What is left unclear in this model is which of these principles can be generalized from coping with acute stressors to coping with chronic stressors. When one responds to a stressor using active coping mechanisms, is there a process whereby this effort becomes a part of one's behavioral repertoire and takes on positive qualities resulting in positive outcomes? For example, if one responds to the low stimulus environment of an isolated and confined environment with an increase in physical exercise and the development of new hobbies, could one anticipate that over time there would be the negative outcomes described by Cohen and his associates? Previous research has indicated that an isolated and confined environment is stressful, and no amount of active coping will change its inherent qualities, and yet exercise and hobbies might ameliorate its more negative qualities without any costs to the organism.

Cohen and his colleagues (1986) do suggest that in the face of ongoing, uncontrollable stressors that palliative, emotion-focused coping efforts may be the best method of responding. However, it is not clear in this model whether there can be ongoing stressors that afford a measure of control, and what the characteristics are that would distinguish these stressors from less controllable chronic stressors.

Finally, there is no explanation of the process or mechanisms by which an organism might successfully adjust or adapt to an chronic stressor. If a stimulus has been appraised as a stressor and if it remains present in the environment, how does an organism cope? The cumulative costs of coping model would suggest that the best one could do is change the meaning of the stressor, or use some other emotion-focused coping strategy to reduce the impact of the stressor. This model does not address the circumstances under which a chronic stimulus initially appraised as a stressor can become a familiar and integral part of the environment, and if changed or terminated could then become stressful because of its absence. Put another way, there may be situations in which organisms successfully adapt to a stimulus initially defined as stressful. If the stimulus is eliminated after an organism has adapted to it, the absence of the stimulus might be stressful.

Habituation/Adaptation Model of Chronic Stress

The third model of chronic stress theorizes that over time organisms will habituate to environmental demands. Physiological arousal will initially be elevated but will return to prestress levels as the organism adapts to the stressor. In situations in which the environmental changes are novel there are research results indicating that the body will show increased heart rate, elevated levels of catecholamines and cortisol, and increased skin conductance (cf. reviews by Frankenhaeuser, 1975; Cohen, et al., 1986; Herd, 1986). With repeated exposure to the same stimulus, arousal levels will return to baseline levels. For example, Evans and Jacobs (1982) report that animal studies indicate that organisms are able to build up tolerance to air pollutants and adapt to them over time. For example, preexposure of laboratory rats to low levels of ozone diminished biochemical responses to subsequent exposure to ozone and reduced the impact ozone on respiratory tract mucociliary clearance (Frager, et al., 1979). Ursin and his associates (1978) found that men exposed to the stress of parachute jumping initially had high levels of cortisol secretions when compared with baseline levels. Over the course of successive jumps the cortisol levels returned to more normal levels. Kasl (1984), in his review of the stress literature, also concludes that endocrine responses are sensitive to acute stressors but that extinction often occurs over chronic or repeated exposure.

The term adaptation has also been used to describe the process of habituating to a stressor. Adaptation is a term used frequently in the stress literature to describe the behaviors, emotions, and physiological mechanisms used to meet the demands of the environment. The term is drawn from the biological literature where it is used to describe an organism's ability to survive through accommodation to the demands of the environment (Dubos, 1965).

Adaptation level theory refers to changes in judgments about stimuli based on experience with those stimuli (Wohlwill, 1974; Helson, 1948). Wohlwill (1974) defines adaptation as "...a quantitative shift in the distribution of judgemental or affective responses along a stimulus continuum, as a function of continued exposure to a stimulus." (p. 134). According to Wohlwill, there may be an optimal level of environmental stimulation for an individual but that optimal level is not intrinsic. The optimal level of stimulation is a product of previous experience. Exposure over time to a relatively stable environment, regardless of the objective level of stimuli present, determines what is perceived as a normal level of environmental stimuli. Individuals respond to increases or decreases in the demands of the environment by shifting their expectations about what is a normal environmental demand.

The habituation/adaptation model of chronic stress is consistent with the adaptation level theory. Habituation or adaptation takes place through an internal shift of reference as to what is considered a normal level of environmental stimulation. This model of chronic stress is also compatible with Stokols' (1979) and Campbell's (1983) suggestion that exposure to stressors over time will reduce the motivational salience of the stressors (the stressors become less important), and that subsequent responses will return to baseline. Dubos' (1965) belief that people have the ability to adapt to their increasingly noxious and stimulus-loaded environment by filtering out unwanted input is also consistent with the habituation model of chronic stress. In contrast to the information overload explanation for filtering out unwanted input, the habituation/adaptation model would explain this ability to adapt to high stimulus environment as a shift in their perceptual judgement as to what represents a normative setting.

A methodological problem of research used to support the habituation/adaptation model of chronic stress is that outcomes from studies conducted over a short period of time are generalized to long term adaptational processes. For example, Herd (1986) discusses the chronic exposure to demanding work settings in a study conducted by Timeo and colleagues (1979) over a four day period. It is not clear that a four day period represents exposure to a chronic stressor.

It is also possible that there may be stressors which organisms can not adapt to. Work by Seligman (1975) and others (Abramson, Garber & Seligman, 1980) have found that settings in which outcomes are not contingent upon behavior, can induce helpless behavior and depression. Experience in this kind of setting may not help an organism to successfully habituate or adapt to the setting. Learned helplessness theory would suggest that the helpless behavior in a noncontingent setting may become generalized to settings where outcomes are contingent on behavior (Seligman, 1975). Cohen and his associates (1980) found this to be the case in their research on children attending school under the flight pattern of an airport. Students in the noisy schools were more likely to give up on problem solving tasks (used to measure learned helplessness behavior) when compared with students attending quiet schools. In this same study the investigators found that with more years of exposure to noise pollution that the effects were stronger. Rather than being able to habituate to the jet noise, the students demonstrated more stress outcomes such as taking longer to solve puzzles and giving up on problem solving tasks more frequently.

Comparison of Models

All three of the models of chronic stress provide a central role for homeostasis mechanisms. The reactivity model of chronic stress asserts that some individuals have a characteristic manner of coping with stressors. This characteristic manner of responding to stressors causes a sharp rise in physiological arousal. This pattern of coping with stressors is theorized to lead to breakdowns of the body's homeostasis mechanisms. In time, after an ongoing pattern of sharp physiological arousal in response to stressors, the feedback mechanisms of the body used to keep the organism from becoming too over aroused become less functional. Specifically, the threshold level becomes higher at which the baroreceptors, and other feedback mechanisms, begin to set in motion signals to reduce the level of arousal. While baseline homeostasis levels of blood pressure and other physiological markers of physiological arousal may remain at the same level, physiological arousal levels in response to stressors become greater because of the damage to these over arousal reducing feedback mechanisms.

The cumulative cost of coping model also focuses on homeostasis mechanisms. This model states that there is a cost of coping with stressors even if the the coping strategy is successful and the stressor is terminated. In contrast to the reactivity model of chronic stress, it is the baseline, physiological homeostasis level which progressively elevates. Chronic, high level of SNS stimulation due to ongoing stressors is hypothesized to reset baseline homeostasis levels higher. This increase in basal homeostasis levels of arousal, in turn, is associated with a subsequent change in the threshold at which the body responds to physiological over arousal. The reactivity model of chronic stress theorizes that the threshold at which over arousal feedback mechanisms begin to dampen the stress response is reset at a higher level, but that baseline homeostatic levels of physiological arousal do not change. In addition, the reactivity model of chronic stress suggests that chronic stress outcomes are due to a stable behavioral pattern of coping with stressors. The cumulative costs of coping theorizes that chronic stress outcomes are due to the toll that a coping strategy can take in response to a stressor. Like the reactivity model of chronic stress, the cumulative costs model focuses on coping strategies. The reactivity model of chronic stress focuses on a repertoire of coping behaviors that are stable in an individual. The reactivity model focuses more on behaviors specific to certain kinds of individuals. The cumulative coping model focuses on coping in a more general fashion. There is more attention paid to the nature of the stressor, and to "cumulative" demands that a stressor can make. In the cumulative costs model coping is treated more as an energy expenditure in response to an environmental demand. Regardless of the successful termination of a stressor, all stressors exact a cost to the body because of energy expended to monitor or terminate the stressor.

The habituation/adaptation model of chronic stress hypothesizes that in response to a chronic stressor the body returns to baseline, homeostatic physiological levels of arousal over time. In contrast to the other two models of chronic stress, the habituation/adaptation model hypothesizes that individuals are able to adapt to ongoing stressors. There will be no permanent change in the baseline or homeostatic level of arousal. The physiological level at which the body responds to reduce over arousal will not change even after extended exposure to chronic stressors. Adaptational processes prevent the permanent alteration of these physiological mechanisms. This adaptation is due to a shift in the organism's perception of what is a normative level of environmental demand. The perception of what is a normative level of demand is based on previous experience rather than intrinsic standards. Unlike the reactivity model of chronic stress, the habituation/adaptation model is not tied to behavioral coping repertoires. In contrast to the cumulative cost of coping model, the habituation/adaptation model indicates that the environmental demands of a "chronic stressor" can become a part of what is considered a normative environmental demand, and as a result this "chronic stressor" loses its negative meaning.

None of these models of chronic stress treat the chronic stress process as a dynamic interface between the changing demands of the environment and the changing perceptions of the individual. In the next section of the chapter I will propose a dynamics model of chronic stress.

Dynamics Model of Chronic Stress

Selye's (1956) model of stress characterized the stress response as nonspecific. Any stressor would elicit the same pattern of physiological responses. More recent research by Mason (1975), Lacey and Lacey (as reviewed in Lacey, 1967), Frankenhaeuser (1975), and Obrist (1981) have demonstrated that the stress response is specific to the parameters of the perceived environmental demand. The specificity model of stress added a dimension to research on the stress process that accounted for the response dynamics observed. The characteristics of both the environmental demand, and the manner in which the individual appraised and coped with the stressor shaped the physiological and psychological response to the stressor.

In a similar fashion, chronic stress has been treated as the accumulation of stress experienced over exposure to a long term stressor. Stress according to this paradigm, is the sum total of the exposure to the stressor. Chronic stress has also been treated as a longer exposure to a stressor than takes place during acute stress. Many of the paradigms used to research acute stress processes are generalized to chronic stress processes without any test of the validity of such generalizations.

In this section of the chapter I will propose that chronic stress is a dynamics process influenced by both objective characteristics of stimuli present in the environment and by subjective changes in appraisal of the stimuli. The term "dynamics" is borrowed from a branch of applied physics that deals with motion and equilibriums of systems that are influenced by forces outside and inside of those systems (Laing & McFarlane, 1972). The term "dynamics" is used to indicate that change over time is an integral component of the model. It also is used to indicate that equilibrium and homeostasis are important aspects of the model.

The dynamics model of chronic stress incorporates many of the ideas developed by researchers who contributed to the reactivity, cumulative costs, and habituation/adaptation models of chronic stress. However, it combines those ideas in a manner that may more accurately portray the nature of the chronic stress process.

Subjective Elements of the Chronic Stress Process

Perception of control in the process of interacting with one's environment is an important psychological mediator between environmental stimuli, stress responses, and stress outcomes. Perception of control is a keystone in the dynamics model of the stress process. The relation between the perception of control, predictable environments, and the ability of an organism to adapt to chronic stressors will be discussed here in order to lay a foundation for the dynamics model of chronic stress.

White's (1959) seminal article on the role of competence defined competence as an organism's ability to interact with its environment effectively. This construct has motivational qualities. Rewards come to the organism as a result of successful interactions with the environment. Successful interactions are those in which the organism's behavior elicits a response from the environment in a predictable fashion. These predictable responses from the environment allow the organism to make future decisions about which behaviors to employ to bring about a desired outcome. The degree to which a setting is predictable determines whether control is possible and whether adaptation to environmental demands will be successful.

Seligman's (1975) research found that noncontingent environments, i.e. settings in which one was not able to determine which behaviors would predictably lead to negative or positive outcomes, would result in learned helplessness. If one is unable to find the underlying structure of behaviors that will lead to positive outcomes and those behaviors that will result in negative outcomes, the opportunities to gain mastery or control over that setting are eliminated.[3,4]

Having a predictable environment allows one to reduce the level of effort required to respond to the environment. Cohen and his colleagues (1986) suggest that by knowing the causal relationships between behaviors and outcomes the organism can reduce the energy required to successfully cope with stressors that occur in that environment. The organism can more quickly choose the coping strategy that leads to the most positive outcome. This is in contrast to being in an unpredictable setting and having to try a variety of alternatives before happening upon a strategy that reduces the environmental demand successfully. Having a predictable environment, or being able to predict outcomes is important even in a chronically stressful situation. For example, Bettelheim (1960) indicates that in the extreme environment of a Nazi concentration camp, those prisoners who were able to develop an understanding of what behaviors minimized negative outcomes in the camp setting were the individuals who survived. Cohen and his associates (1986) suggest that having a predictable environment, even when stressors such as noise are present, is less stressful than an unpredictable setting because less monitoring of the environment is required.

Novel stimuli introduce an element of unpredictability into a setting. Novel stimuli are by definition, unknown and therefore unpredictable environmental demands. Because novel stimuli are unpredictable, they may originally be appraised as threatening or harmful and result in a higher level of physiological arousal and negative emotions. As more is learned about the novel stimulus through repeated or continuous exposure to it, the stimulus may be reappraised as predictable and subsequently less threatening (Glass & Singer, 1972). Research results using both animal models (Kant, et al., 1985) and human models (Ursin, et al., 1978) support this hypothesis. For example, Pitman and his associates (1988) exposed rats to restraint stressors for short periods of time over seven days. Plasma corticosterone responses, calculated by subtracting basal levels from those measured one hour into the stressful condition, declined over the seven days of exposure to the stressor.

Initial exposure to novel stimuli result in heightened stress outcomes compared to baseline levels. When stimuli remain present at the same levels, stress outcomes decrease over time. It might be expected that the introduction of a new environmental stimulus, or any environmental change, might introduce an element of unpredictability to a setting that would result in initial elevations of physiological and psychological arousal. As the new stimulus becomes predictable, physiological and psychological outcome levels would return to baseline levels.

When an environmental setting is predictable then control or mastery over the setting may become possible. Cohen and his associates (1986) have suggested that control's role in mediating the stress response can be understood in terms of the function control has in the organism's interactions with the environment. Control has the potential to enhance self image by giving the individual feedback about their mastery over the environment. Coping responses can be thought of as the organism's effort to gain mastery over the demands of the environment.

According to this perspective on control, stress is an outcome of the effort expended to respond, or cope with the environmental demand. The more successful the organism is in mastering the environmental demand, the less stress is experienced in the long run. Mastery may not be associated with terminating the stressor in all situations. When it is not possible to terminate the stressor, more palliative, emotion-focused forms of coping may reduce the level of stress experienced. Campbell (1983) provides an example of how people can successfully reduce the environmental demands of a stressor. She believes that individuals reappraise ambient, chronic stressors such as air pollution, as benign entities. In response to these ambient stressors, individuals make a conscious decision to tolerate the stressor because other rewards are associated with being exposed the ambient, chronic stressor. For example, the high paying jobs found in Los Angeles may counter balance the negative aspects of living in a low air quality environment.

Control is an important component in the response to a chronic stressor. In a study at Three Mile Island of the effects of the chronic stress associated with exposure to radiation, Baum and O'Keefe (unpublished manuscript) report that perception of control among the residents of Three Mile Island was positively correlated with higher task performance, lower reports of distress, and lower levels of catecholamines and cortisol. Karasek (1979) found evidence that jobs which afford low decision latitude (low control) but which are demanding were associated in the Swedish work force with increased incidences of heart disease.

Adaptation was introduced earlier in this chapter as the psychological process by which individuals are able to habituate to an ongoing stressor. To review briefly, the adaptation process refers to the organism's ability to accommodate to environmental demands (Dubos, 1965). Wohlwill (1974), a proponent of adaptation level theory, suggests that an important facet of the adaptation process is the ability of an individual to shift her or his frame of reference as to what is considered a normative level of environmental stimulation as a function of recent experience. The dynamics model utilizes the adaptation level theory. This perspective on adaptation is different from the cumulative costs of coping view of adaptation. The costs of coping model indicates that adaptation has physiological and psychological costs to the organism even if the adaptational process is successful in ameliorating the stressor. The cumulative costs of coping model does not utilize the idea that an organism has a "relative" perception of what is considered an optimal level of environmental stimulation based on recent experience.

I propose that adaptation includes the process whereby an organism placed in a new setting learns the underlying structure of rules that makes a new environment predictable. The organism gains mastery over the environment by being able to make deductions about outcomes because of the the repetitive presentation of the underlying structure of the setting. Kirtz and Moos (1974) refer to this as the dimension of clarity in a setting. At first a new setting or a change in the stimuli present in the setting is novel and unpredictable. Control over the setting takes place as time passes and the environment becomes known and predictable.

The paradigms of "perceived control," predictable environments, and adaptation are conceptually connected. Perceived control allows the organism to increase mastery over an environmental setting and reduces physiological and psychological arousal levels to baseline or near baseline levels. A predictable environment is one in which the underlying structures of behaviors and their consequences are known. A predictable environment affords the organism, at least a form of perceived control over the environment because the organism knows what the outcomes of its behavior will be. Adaptation is the process by which an organism learns the rules of behavioral consequences in a new setting and makes the setting predictable. Adaptation also refers to the manner in which recent and current experience shapes what an organism considers to be a normative setting. A person labels the normative level of stimulation in a setting the level of stimulation that occurs most frequently in the person's recent experience. If the average level of stimulation in a setting shifts upwards or downwards over time so does the organism's perception of what represents a normative stimulation level for an environmental setting. This implies that an organism is able to shift its expectations about what is a normative setting and learn new rules of behavioral consequences in order to make new environmental situations and settings predictable. As new settings become predictable, the organism increases its mastery over the setting. This increase in perceived mastery/control permits the organism to reduce heightened levels of physiological ınd psychological arousal to baseline or near baseline levels.

Time is an important element in the adaptation process. Longer exposure to a stimulus or stimuli provides additional opportunities to discern causal relationships between behaviors and subsequent outcomes. Additional experience with a stimulus or set of stimuli helps shape the organism's shifting sense of what is a normative setting. Novel stimuli are arousing precisely because they are new and unpredictable to the organism. The longer the period of time an organism is exposed to a stimulus the more opportunities the organism has to learn predictable outcomes associated with the stimulus.

Adaptation can be thought of as behavioral process by which an organism can return to baseline levels of physiological and psychological levels of arousal. It can be compared to internal physiological homeostatic feedback mechanisms. When an organism is presented with a new stimulus or stimuli it responds typically with increased physiological and psychological arousal. As the organism learns the causal relationships between behavior and outcomes, and as the organism shifts its perceptions of what is considered a normative level of environmental demand, the stimulus/stimuli becomes predictable. The predictable quality of the environmental demands and habituation to those demands increases mastery of the organism over the setting. This reduces the effort required by the organism to monitor the stimulus or stimuli. The reduction in effort required to monitor the setting, in turn, reduces physiological and psychological levels of arousal.

A changing environment places demands upon an organism because it is unpredictable and unpredictable environmental demands may represent a threat. If the magnitude of the threat is large then unless the threat of the environmental demand is reduced or eliminated the internal physiological and psychological resources required to meet the demand can be exhausted. Selye's (1956) work with animals and stressors demonstrated that permanent physiological damage or death can occur if exhaustion of internal resources occur. If the stimulus is acute in nature and is terminated, then the demand the stimulus represents is terminated and physiological and psychological arousal levels can return to normal. However, if the stimulus is chronic, the organism needs a mechanism whereby it can reduce the demands of the chronic stimulus. The ability of an organism to continually be able to learn new rules about relationships between behavior and consequences in a changing environment over time, and the ability of an organism to shift what is considered a normative setting is a mechanism whereby the organism is able to maintain physiological equilibrium. A stimulus which might have been originally perceived as a threat because of its novel and unpredictable nature, can lose its threatening quality as it becomes predictable. As the stimulus loses its threatening qualities because it becomes more predictable the environmental demands it represents diminish. As the demands diminish, the energy required to monitor the stimulus decreases. This reduction in energy translates to a return to baseline physiological and psychological arousal levels.

To summarize, the body has physiological feedback mechanisms that help maintain internal physiological homeostasis. Adaptational processes are hypothesized to play similar homeostatic role in the face of chronic environmental stimuli. The ability of the organism to learn causal relationships underlying behaviors and subsequent outcomes, and the ability of the organism to shift along a continuum of what is perceived to be a normative level of stimulation in a setting, are thought to be the mechanisms of the adaptational, homeostasis process. Over time, the chronic stimuli represent less of an environmental demand because the organism learns causal behavioral relationships associated with the stimulus making it predictable. Because the stimulus is predictable it affords the organism a form of control or mastery over the environment. In addition, over time as the chronic stimuli becomes a part of the organism's experience and is an expected part of an environment, the organism's perception of what represents a normative level of environmental stimulation expands to include the chronic stimulus. This adaptational process allows the organism to maintain a homeostatic balance of physiological and psychological arousal over time rather than exhausting internal resources to meet the ongoing demands of the environment. This adaptational process can occur even when the predictable, chronic stimulus remains present in the setting.

Chronic stimuli which are unpredictable will continue to require additional energy to monitor them. Unpredictable stimuli have no discernible rules about their occurrence or outcomes, and as a result can not be adapted to. Physiological arousal may remain elevated in response to unpredictable chronic stressors. This was the case at Three Mile Island more than a year after the nuclear accident (Fleming, et al., 1984). The unpredictable nature of the outcomes from that incident and the ongoing health threat it presented were hypothesized by the investigators to explain the elevated levels of blood pressure and catecholamines found in the residents of Three Mile Island. An organism may be able to limit the energy expended on monitoring an unpredictable stimuli through palliative coping mechanisms (see reference note 3). Evans and his associates (1982) found this to be the case with residents who had lived for a long time in Southern California's air polluted neighborhoods. These long time residents more typically used emotion-focused coping strategies to respond to the unpredictable chronic stimuli, air pollution.

The discussion of the dynamics model to this point has described two processes that may take place in response to chronic environmental demands. The first is an adaptational process drawn from the habituation/adaptation model of chronic stress. This adaptational process is considered a behavioral mechanism that allows the organism to maintain an internal equilibrium psychologically and physiologically in the face of ongoing demands by the environment. The dynamics model is different from the habituation/adaptation model because it theorizes that unpredictable chronic stimuli can not be adapted to.

The second process is drawn from the cumulative costs of coping model of chronic stress. When a chronic stimulus is unpredictable in nature the dynamics model would theorize that it will not be possible for an organism to adapt to it. There will continue to be a non-normative level of physiological and psychological arousal. This stress process associated with unpredictable chronic stimuli is similar to the cumulative cost of coping model because it suggests that there will be an ongoing expenditure of energy as a result of coping with unpredictable chronic stressors. The dynamics model is different than the cumulative costs of coping model for two reasons. The first is that the stress experienced in association with unpredictable environmental stimuli is not expected to be cumulative in nature. The dynamics model is also different than the cumulative model of chronic stress because the dynamics model theorizes that predictable chronic stimuli can be successfully adapted to with no cumulative costs of coping.

Environmental Dynamics

The chronic stress process is a reflection of the objective components of an environmental setting as well as the more subjective elements of appraisal discussed above. This section of the chapter discusses the part that the setting plays in the chronic stress process. The dynamics model of chronic stress suggests that the environment contributes greatly in the stress process. The role of the environment is due to both the additive nature of the multiple environmental stimuli present in a setting at any one point in time, and the influence of change over time in the array of stimuli present in a setting. The dynamics model of chronic stress proposes that the term "process" implies a time dependent series of events. It is suggested that studies of chronic stress that exclude the changing nature of the environment over time are unable to measure the dynamic properties of the stress process.

At any one point in time the environmental demands made on the individual depend on the acute and chronic stimuli present in a setting. No stimulus exists alone. Arousal theory suggests that each of these acute and chronic elements in a setting has an additive nature (Hockey, 1979). Some of these stimuli may be physiologically arousing, while others are physiologically depressing. Some stimuli are physical in nature (air quality, temperature, population density, physical confinement), while others are social (crowding, social support, social events). The demand on the organism at any one point in time is a function of the additive, sum demand of the stimuli present in the setting. Arousal theory proposes that when stressors of an arousing and depressing nature are both present, they can cancel out each others effects. Likewise stimuli which have a similar arousal influence will have an additive influence when combined. These kinds of additive effects of multiple stressors have been found most extensively in the area of task performance research (Hockey, 1979; Broadbent, 1971). The idea of measuring the additive impact of multiple environmental stimuli is not a new concept in the study of stress. Many studies account for the presence of more than one stressor. For example, Carrere and her associates (unpublished manuscript) measured traffic congestion and levels of air pollution in a study of Type A bus drivers and occupational stress. However, what studies of chronic stress processes do not do is examine how ongoing changes in environmental stimuli present in a setting influence stress outcomes.

Change in and of itself requires increased energy by the individual to appraise and monitor stimuli. Even when that change is predictable it can result in stressful outcomes. The influence of change is tied to the adaptation level theory presented earlier and the discussion of novel stimuli. One's perception of normative environmental demand is based on experience. When the level of stimulation changes in a setting the initial period following that change may be perceived as a non-optimal level of environmental demand. This can occur regardless of whether the change reflects an increase or decrease in the number of stimuli, or a change in the intensity of the stimuli present in the setting. Making the transition to an isolated and confined setting is thought to be stressful because of the low level of stimuli present in the setting

(Rasmussen, 1973). However, the stress that is experienced in adapting to a lower level stimulus environment may be due to the shift in level of background stimuli rather than the intrinsic qualities of the setting. Oliver's (1979) study found that for many winter residents of Antarctica the transition from Antarctica to the relatively high stimuli environment of the United States was more stressful than getting used to Antarctica.

Chronically stressful settings are not usually examined in terms of their changing nature over time. The chronic stress process has typically been treated as an interface between an ongoing stressor that is static in its objective nature, and the psychological and physiological outcomes resulting from from the static demands of the setting. For example, the Three Mile Island research compared individuals from Three Mile Island with people from other settings in which exposure to radiation did not occur (Baum, et al., 1983). Baum and Davidson (unpublished manuscript) speculated that the stress associated with the uncertainty of future health outcomes due to the radiation exposure could explain the higher levels of helplessness found among the residents of Three Mile Island. What these researchers did not do is look at the changing environmental demands at Three Mile Island over the course of their research and the dynamic influence those changing demands had on stress outcomes observed. We can learn about chronic stress processes not only by looking at between group differences, but also by looking at within group changes in response to changing environmental demands over time. It is important to consider the role that a changing environment can play in the stress process. We know from previous research that the presence of multiple stimuli in a setting can have an additive influence on stress outcomes. We also know that change in a setting can increase stress outcomes. The dynamics model of chronic stress suggests that both alterations in the array of acute and chronic stimuli present in a setting, and change in and of itself contribute to chronic stress outcomes. When theories of chronic stress exclude the changing nature of the environment over time, they have excluded an important source of variance in predicting stress outcomes.

The dynamics model of chronic stress is different from other models of chronic stress because it considers the environment a dynamic entity that changes over time. The model proposes that to comprehend the chronic stress process it is important to understand and measure the manner in which changes in the environment influence stress outcomes.

Comparison of the Dynamics Model with other Models of Chronic Stress

This perspective on the chronic stress process is different from the other models of chronic stress reviewed in this chapter. The reactivity model of chronic stress focuses on the behavioral repertoire of coping behaviors associated with hypperresponsive arousal and the stimuli that elicit those kinds of responses. The reactivity model does not examine the interface between a changing environment and subsequent responses by the individual. The influence of length of exposure to a stressor (important in adaptational processes as discussed earlier) is also not a consideration in the reactivity research. For example, Houston and his associates (1989) exposed individuals to a series of conditions expected to discriminate between hyperresponsive and normative individuals. The conditions consisted of a baseline, performance of a mental problem with cognitive dissonance components under hurried conditions (Stroop test), a rest period, a mental subtraction task under pressure, and a final rest period. Rather than measuring changes in the setting and subsequent changes over time in the outcome measures, the environment for each condition was considered a static force, and the physiological outcomes were averaged for each stress condition and resting period. At first glance this appears to be a measure of change in both the environment and in the individual. However, each condition is treated as a static, composite environmental variable that does not change over the course of its presentation. This is evident in that there is no attempt to quantify the change in the social and physical environmental variables during each condition even though the instructions to hurry the assigned task take place midway through the condition. Secondly, the outcome of a condition is based on an average of the physiological measures taken during that condition. It does not consider change in the stress outcomes as a function of length of exposure to a stressor or as a function of changes in the stressor. This study is representative of the kinds of research designs used to examine the reactivity paradigm. The changes in the environment that take place during a condition and the influence it has on the outcome measures used can not be measured using this research strategy.

The cumulative costs of coping model of chronic stress has been tested using both cross sectional and longitudinal studies measuring the influence of multiple environmental variables on stress outcomes (e.g. Glass & Singer, 1972; and Cohen, et al., 1986, respectively). The cross sectional studies often take stress outcome measures under baseline conditions and static environmental conditions presumed to be stressful using research designs similar to those described above for Houston and his associates (1989). Alternatively, other cross sectional studies compare stress outcome measures for individuals under conditions presumed to be stressful with those outcomes of a control group (e.g. Stokols, et al., 1978). The cross sectional studies used to test the cumulative costs of coping model have not addressed the role of change in an environment.

Longitudinal studies are either epidemiological in nature or only use several time points to measure stress outcomes. Neither of these longitudinal research designs considers or measures changes in the environment in order to interpret the observed outcomes. For example, one the better longitudinal studies that examined the cumulative costs of coping was conducted by Cohen and his associates (1986). Children attending schools under the Los Angeles International Airport jet approach route were studied to learn about the stress outcomes associated with their noisy environmental conditions. These students were compared with students attending quiet schools. In addition, the multiple environmental stimuli in their school and home settings were measured (e.g. residential noise, residential density). The years of exposure to the jet noise in the schools was also evaluated. A year after the initial study stress related outcomes for a subsample of these students were measured. This research did take into account the influence of multiple environmental demands, length of exposure to the primary stressor, and measured stress outcomes more than once. A limitation of this study is that it assumes that the impact of the environmental stressors are static forces and that the environment does not change over time. One can imagine that the outcomes measured on any one day may be influenced not only by the environmental variables measured, but also by the changing dynamics of the study participants's environment. The other limitation of this kind of research design is that it assumes that stress outcomes are representative of the cumulative impact of the exposure to the environment. It is possible that the outcomes may be more representative of discrete events occurring closer in time to the measurements of stress.

Research designs used to test the habituation/adaptation model of chronic stress are frequently similar to those described for the reactivity and cumulative costs of coping models. The other kind of research design used to test the habituation/adaptation model measures stress outcomes over time in response to a continuous or repeated presentation of a single stimulus (e.g., Ursin, et al., 1978). The focus is on adaptation to the stimulus and may not generalize to situations in which there are multiple stimuli changing over time. This may be especially problematic when stimuli are changing in a fashion that is not synchronous. This is to say, each stimulus may change in a manner independent of the changes that occur in the other stimuli present in a setting. For example, one can imagine that starting a new job may be stressful because of the unpredictable nature of the new situation. Changes in that individuals home environment, changes in job demands, and fluctuation in environmental demands such as air pollution and commuting traffic congestion may make different kinds of demands on the individual at any one point in time, and across time. In addition these demands are unlikely to fluctuate in a synchronous fashion. There may be an additive or interactive process of adaptation when more than one stimulus is present.

The dynamics model's emphasis is on change in the environment and subsequent changes in the individual's stress outcomes. This perspective on the stress process is unique to the dynamics model of chronic stress. It is a tenant of this model that it is necessary to examine both the variation in the environment and subsequent changes in stress outcome measures in a time-ordered fashion. If one uses the measurement strategies utilized to test the reactivity, cumulative costs, and habituation/adaptation models one will miss the interdependent roles of both time and fluctuations in environmental demands on stress outcomes. The change in stress outcomes due to fluctuating environmental demands is the dynamic component of the stress process. If chronic stress is a process that involves person-environment transactions over time, then both the variance in environmental demands and individual outcomes must be measured frequently over time.

It is difficult to imagine a chronic stressor that is a static force except in the controlled environment of the laboratory. Every environment changes. Some stimuli may remain present at a constant level, but within any setting environmental demands will change. Kinsey (1959) describes the adaptation to the month long cruise of the submarine "Nautilus" under the North Pole as a dynamic process involving changes in both the environment and the psychology of the crew. Earls (1969) also describes adaptation on board a nuclear submarine during the 90 day submerged patrol as a dynamic process. Each period of the 90 day cruise took on a different meaning for the crew as they progressed from becoming reacquainted with the submarine, to becoming immersed in the routine of the ship, and finally anticipating the end of the patrol.

The dynamics model of the chronic stress proposes that the stress process, over time, reflects the changing interface between individuals and the acute and chronic elements of their environment. It is a dynamic process that involves an ongoing transaction between the individual and his or her environment. The environment is not a static composite but rather changes over time due to both changes in stimuli intensity and the array of chronic and acute elements present. In addition, people may be able to adapt to stimuli over time if the causal relationships between behavior and outcomes can be learned for those stimuli. Learning causal relationships helps to make the stimuli predictable and provide the individual with a form of mastery over the environment. The ability of an organism to discern causal relationships between stimuli and outcomes, as well as the ability of the organism to shift its perception of what represents a normative level of environmental stimulation based on recent experience, may provide the organism with a homeostatic mechanism to prevent the exhaustion of internal resources. These changes in both the environmental demand and the perceptions of the environment by individuals creates a dynamic person-environment interaction that is at the heart of the chronic stress process.

Rationale for Research on the Dynamic Qualities of Chronic Stress

The purpose of the present study is to examine the dynamic person-environment transactions in a setting that previous research on isolated and confined environments has found chronically stressful. The research sets out to compare the dynamics model of chronic stress with both the cumulative costs of coping model of chronic stress and the habituation/adaptation model of chronic stress.

The dynamics model of chronic stress offers both a new perspective on the chronic stress process and principles that can be tested. The perspective of the dynamics model of chronic stress is that stress outcomes are a reflection of the ongoing dynamics of environmental demands over time and the responses of the individuals to those changing demands. The dynamics model of chronic stress proposes that the following principles are important in understanding the chronic stress process.

1. Time-ordered change in the environment, both the sequence of that change and the duration of the stimuli introduced by the change, influences the ability of individuals to adapt to stimuli. Time-ordered change contributes to stress outcomes observed.

2. Change in the intensity of stimuli or the array of acute and chronic stimuli present in a setting can alter the environmental demand of a setting and have an impact on stress outcomes observed.

3. Environmental demands are not static over time. The demands of a setting change continually as a function of objective changes in the environment and as a function of changes in subjective appraisal of components of that setting.

4. Stress outcomes are not due as much to the cumulative costs of coping with a stressor over time as they are a reflection of responses to environmental demands more proximate in time.

5. The predictable or unpredictable qualities of new stimuli introduced into an environmental setting are considered important factors in the ability of an individual to adapt to these stimuli. Predictable stimuli can be adapted to when there is enough time to learn underlying causal relationships between behavior and outcomes. Unpredictable stimuli require increased internal resources to be monitored because causal links between behavior and outcomes can not be determined. For these reasons, unpredictable chronic stimuli are expected to be associated with ongoing stress. The responses to the unpredictable stressors are not anticipated to be cumulative in nature.

It is beyond the scope of this research to test all of these principles of the dynamics model of chronic stress. The study does examine some of the ways the dynamics model of chronic stress differs from the cumulative costs of coping model of chronic stress and the habituation/adaptation model of chronic stress.

The cumulative costs of coping model would predict that there is cost of coping with stressors regardless of whether the coping strategy is successful or not. This cost is cumulative in nature. The cumulative costs of coping model would predict that over time stress outcomes would increase as the length of exposure to a stressor increases. The best representation of this time-related association between duration of exposure to a stressor and stress outcomes would be a linear trend, representing an increase in stress outcome levels as length of exposure increases. The dynamics model of chronic stress would hypothesize that individuals are able to adapt to predictable stimuli over time. The dynamics model would also predict that individuals would not be able to adapt to unpredictable stressors over time. In addition, the dynamics model would hypothesize that stress responses to unpredictable chronic stressors would not be cumulative over time but more specific to the level of the stressor at any point in time. In this study I examine the relationship between acute and chronic stimuli in the environment and subsequent stress outcomes by taking weekly measures of both environmental stimuli and stress outcomes and analyzing the sequential association between the environment and stress outcomes using time series techniques. The time series techniques permit consideration of not only the influence of environmental stimuli on well being but also the influence of change over time in the demands of the setting on outcome measures.

The habituation/adaptation model of chronic stress would predict that the participants in this study would be able to adapt to chronic stressors in the environment. This hypothesis, drawn from adaptation level theory, would propose that the study's participants will be able to adapt to the low stimulus winter setting of Antarctica and the other chronic subcomponents of this environment. Like the dynamics model of chronic stress, the habituation/adaptation model would predict that the participants in the study would show no ongoing increases in stress over the winter due to the predictable low stimulus ambient environment of Antarctica. Unlike the dynamics model of chronic stress, the habituation/adaptation would hypothesize that individuals would also adapt to unpredictable stressors such as weather. There might be an initial increase upon exposure to a novel stressor, but with time, the habituation/adaptation model of chronic stress would propose that stress outcome measures would return to baseline levels. In contrast, the dynamics model of chronic stress would hypothesized that if the chronic stressor is unpredictable, the study participants would not be able to adapt to that stressor. The stress outcome levels observed would be associated with concurrent levels of the unpredictable stressor (rather than increasing over the time of exposure as the cumulative costs of coping model of chronic stress would predict).

This study also extends what is currently known about chronic stress processes by taking weekly measures of physiological and psychological responses to an environmental setting considered to be chronically stressful in order to track temporal interactions between the study participants and their environment. Rather than treating the tenure in Antarctica as a static, homogeneous demand on the participants, fluctuating physical and social components of the setting were measured in order to examine the sequential relationships between change in the environment and stress outcomes. The use of frequent measures of both changes in the environment and stress outcomes permits a more detailed examination of the chronic stress process. Most chronic stress studies have either used outcome measures at the end of an exposure to a chronic stressor (or stressors), or at several points over the course of exposure to the stressor to characterize the impact of that stressor. In contrast, this research more closely considers the roles of multiple acute and chronic stimuli making up the environment; changes in that environment; and time itself in contributing to the variance observed in chronic stress outcomes. By examining the temporal interaction of humans and their environment it may be possible to learn more about the chronic stress process and the adaptational ability of humankind.

Reference Notes

1. There are large bodies of research that have treated the relative weight of environmental factors in the etiology of disease (see Evans, 1982, and Stokols & Altman, 1987, for reviews of this literature), as well as the degree to which psychological components increase susceptibility to disease (see Lazarus & Folkman, 1984, and Gentry, 1984, for overviews of this literature). Reviews of these literatures have been written elsewhere and will not be repeated here so as to not wander from the main arguments of this chapter.

2. The latency of the return to baseline physiological arousal levels may be a crucial variable in understanding the physiological mechanisms linking reactivity and increased risk for coronary heart disease. For example, increased blood pressure is associated with turbulent blood flow. Turbulent blood flow can cause blood vessel damage (West, 1985). The length of time that blood pressure is elevated such that turbulent blood flow is occurring could influence the risk for CHD.

3. It is possible that in an unpredictable environment that a form of control can be gained by the helpless response. A helpless response could be construed as a strategy to minimize the impact of the noncontingent stressor. It may be the most control available to the organism in that kind of situation. If an organism can not terminate a stressor, or even know if its efforts are effective, the most mastery possible would be to limit the energy expended on the stressor.

4. Abramson and her associates (1980) have reformulated the learned helplessness paradigm and have proposed that it is the attributions one makes about the process that determines the outcomes. If an individual can attribute failure to a lack of effort versus a lack of ability, then the outcome is less likely to result in learned helplessness. This can be considered a form of control. If one perceives that the environment is not predictable only because one has not made an effort, a form of mastery is retained. The sense here is that the individual could gain control if he or she tried hard enough.

Chapter Three

Hypotheses

This research employs combination of bivariate and interrupted time series techniques to examine social and physical factors that influence human adaptation in an Antarctic research station during the winter season. The time series analysis procedures provide a model of sequential environment-person transactions in a chronically stressful setting. This research uses frequent measures of physiological arousal and psychological mood over a six and a half month austral winter to examine acute and chronic stress processes. It examines the dynamic influences of discrete and ambient environmental factors on well being rather than treating the physical setting as a static, composite variable. As a result, this study extends knowledge about both chronic stress and isolated and confined environments.

A variety of physical and social variables were believed to influence the level of stress experienced during the six and a half months of the Antarctic winter. The chronic elements of the environment included the length of stay in the ICE and the weather. Acute factors in the setting were the festivities and the arrival of a new station crew at the end of the winter.[1] Different environmental factors combine to create a setting that changes in quality over the course of the winter season. The role that each of these factors is thought to play will be discussed in more detail below.

Length of Stay in an Isolated and Confined Environment

Environments perceived as stressful place demands on individuals. Previous research on the winters in Antarctica indicated that Antarctic settings are chronically stressful to many inhabitants. There may be predictable ambient qualities (e.g., darkness, low stimulus level) of the isolated and confined environment of Antarctica that define the unique characteristics of that polar setting. These ambient features of the setting can be thought of as synergistic in nature. While there are many components of the Antarctic setting that can be pinpointed and measured, there are also holistic qualities of the ICE setting.

Stress in the Antarctic setting may be due to the costs of adapting to the demands the ambient environment makes on individuals. The cumulative costs of adaptation model of chronic stress theorizes that over time the costs of adapting to a stressful situation are manifested in physiological arousal and negative mood change (Glass & Singer, 1972; Cohen, et al., 1986; Frankenhaeuser & Johansson, 1986). Based on the outcomes of previous Antarctic ICE research and the costs of adapting model of chronic stress, it was hypothesized that the length of stay in a long-term isolated and confined environment would be associated with increases in blood pressure, catecholamines, and cortisol. Environmental stimuli which are negative in quality and require effort to adapt have been associated with increased activation of both the SAM axis and HPAC axis (Lundberg, 1980; Frankenhaeuser & Johansson, 1986). Increases in catecholamines and blood pressure are associated with elevated activity of the SAM axis. Increases in the secretion of cortisol is associated with elevated activity of the HPAC axis. The arousing nature of the chronic stress hypothesized to be associated with the length of stay in Antarctica was expected to lead to higher levels of anxiety and hostility but not increased levels of depression.

An alternative hypothesis was also proposed. If the predictable, ambient quality of the polar setting could be adapted to (in accordance with the habituation/adaptation model of chronic stress and the dynamics model of chronic stress), one would expect no linear increase in any of the physiological measures of arousal. Under this alternative hypothesis negative self reports of mood would not increase over the stay in Antarctica.

Weather

The harsh weather conditions in Antarctica play a major part in restricting physical activity. Poor weather conditions can confine individuals indoors for extended periods of time. Physical confinement has been shown to have stressful outcomes (Haythorn, 1973; Altman & Haythorn, 1967; Taylor, Wheeler, & Altman, 1965). Rivioler's work in Antarctica has also indicated that weather conditions may influence stress levels (1974).

Strong winds are the major weather element that prevent people from going outside in those parts of Antarctica north of the Antarctic circle.[2] Wind speed was expected to have a positive, synchronous relationship with blood pressure, catecholamines, cortisol, hostility, and anxiety.

Festivities

Special events such as parties and holiday celebrations add a bit of pleasant novelty to an otherwise very predictable environment. A lot of time, effort, and planning goes into making these events take place. Such efforts include food preparation, the manufacturing of costumes or importation of formal attire, scavenging through station supplies for presents, unusual presentations, and room decorations.

During the winter that the current research was conducted there were several periods when festivities took place. The first period was termed "Palmer Party Days" because during a two week period in June there were five birthday parties and a winter solstice celebration. The birthday parties involved special dinners, the manufacture of home made cards, and the production of video tapes or activities tailored to tease the guest of honor. The winter solstice celebration is an Antarctic holiday during which the research stations of different nations send each other radio messages of cheer and good luck for the winter season. Winter residents of Palmer Station may "officially" join the Penguin Club beginning on this date. Members of the Penguin Club are those who have jumped into the sea water and submerged their heads before climbing out. The solstice holiday is topped off by a day of no work and an evening of good food and a party in the lounge.

The second festivity period centered around July fourth and consisted of a fishing contest for both the most fish caught and the largest fish caught; a special picnic dinner; and fireworks.

The third festivity period took place towards the end of the winter and consisted of a two week period during which a series of events took place. A British research ship visited the station for several days and parties were hosted at the station and on board the British ship. Also during this two week period a Canadian crew and their plane were forced to land at the station and stay overnight because of poor weather at their original destination. An impromptu party was held for them. In addition, Halloween took place during this third time period. A party with homemade costumes (that took some several days to construct) was held to celebrate Halloween.

The weeks during which these extensive festivities took place were hypothesized to be periods in which blood pressure and the catecholamines were expected to be significantly elevated. Cortisol levels were expected to remain unchanged. Self reports of anxiety, hostility, and depressions were expected to be lower during the weeks of the festivities. These outcomes were anticipated because these periods were environmentally demanding, but the stimuli was not of a negative nature. This kind of environmental demand would result in physiological arousal but not distress or other negative affective states (Frankenhaeuser, 1975).

Summer Crew Exchange

At the end of the winter the crew for the next year arrives. There is a one to two week period of time during which both the winter crew and the new crew are at the station. The year this study was conducted the overlap of crews lasted a week. This week represented a great change in the station from the previous winter months. The station population almost quadrupled. Areas that were used by a member of the winter staff for work or as a bedroom were turned over to the new crew or had to be shared with the newcomers. The station took on a more institutional ambience that had not been present during the winter months. New rules for use of public areas at the station were implemented. Furniture was rearranged from cozy configurations that could be used by a small number of people, to configurations that large numbers of people could use. For example, during the winter months in the dining room several tables were pushed together to make one large table and the other extra tables were stored. When the summer crew arrived the tables were arranged cafeteria style to maximize the number of people who could eat at one time.

This transitional period at the end of the winter was hypothesized to increase environmental demands that would be perceived as threatening, overwhelming, and overall as a negative event. Physiological measures of blood pressure, catecholamines, and cortisol were expected to be significantly elevated during this time period because of the negative nature of the event and because of the increase in environmental demands. Self reports of anxiety and hostility were also expected to be significantly increased during this time period.

Hypotheses

1A. The cumulative costs of coping model of chronic stress: The length of stay in the isolated and confined environment of Antarctica was expected to be associated with:

<u>Physiological Measures:</u> increases in blood pressure, and waking, 8-hour urinary measures of epinephrine, norepinephrine, and cortisol.

<u>Psychological Self Report Measures:</u> increases in hostility and anxiety. No significant change in depression.

1B. The dynamics model of chronic stress and the habituation/adaptation model of chronic stress: The length of stay in Antarctica would be associated with :

<u>Physiological Measures:</u> no increases in blood pressure, or waking, 8-hour urinary measures of epinephrine, norepinephrine, or cortisol.

<u>Psychological Self Report Measures:</u> no increases in hostility, anxiety, or depression.

2. The degree of physical confinement due to harsh weather was hypothesized to be associated with:

<u>Physiological Measures:</u> a synchronous positive relationship with blood pressure, and waking, 8-hour urinary measures of epinephrine, norepinephrine, and cortisol.

<u>Psychological Self Report Measures:</u> a synchronous positive association with hostility and anxiety. No significant change in depression.

3. Festivities were expected to be positive events at the station and to have an association with:

Physiological Measures: increases in blood pressure, and waking, 8-hour urinary measures of epinephrine and norepinephrine. No significant change in urinary cortisol measures were expected because the events were demanding but were not of a negative nature.

Psychological Self Report Measures: decreases in hostility, anxiety, and depression.

4. The period during which the station was turned over to the new summer crew was expected to be associated with:

Physiological Measures: increases in blood pressure, and waking, 8-hour urinary measures of epinephrine, norepinephrine, and cortisol.

Psychological Self Report Measures: increases in hostility and anxiety. No significant increases in depression were expected.

Reference Notes

1. The change in day length is also a chronic component in a polar setting. The influence of the day length was not possible to measure because of the systematic nature of the change in day length and the lack of a comparison group in a setting with a different sequence of day length.

2. South of the Antarctic Circle the absence of sunlight during the winter may be another factor that restricts people to the built environment.

Chapter Four

Methods

Subjects: Nine of the twelve inhabitants of Palmer Station, Antarctica, who wintered during the months between April and October, were the subjects for this research. Four of the subjects were scientists conducting winter research at the station (see Table 4.1). The remainder of the subjects were support personnel responsible for the day-to-day operations of the facility. The investigator was the only female at the station. Although the investigator participated in all aspects of the study, her data were not included in the analysis because gender differences could have introduced additional variance into the data not due to the variables of interest. All of the study participants whose data were used in the analyses were males. Ages ranged between 26 and 43. All of the participants in the study had attended college. Several of the

Table 4.1 Demographic Information

	Mean	Standard Deviation	Range
Age of Study Participants	32.56	4.99	26 - 43
Years of Education	17.22	2.82	14 - 22
Study Participants who had spent at least one previous winter in Antarctica	3		
Scientists	4		
Station Support Personnel	5		

subjects had previous experience in Antarctica (four), and three of those individuals had previously spent a winter in Antarctica. The station members who did not participate in the study were similar to the study participants in age, education, previous Antarctic experience, and job status.

Dependent Variables

This research used multiple measures of stress and arousal to develop a robust picture of what individuals exposed to a long-term isolated and confined environment were experiencing. The choice of outcome measures and the design of the study were made, in part, to address threats to validity. One threat to construct validity is the use of a singular form of recording outcomes, mono-method bias (Cook & Campbell, 1979). To meet this threat both physiological measures and psychological self-report measures were used to index the underlying mechanisms of stress and arousal experienced in this research setting.

Physiological Measures: A diversity of physiological outcome measures were used in this research because physiological responses to environmental demands can take different forms. Activation of the sympathetic-adrenal medullary axis (SAM) arouses the body, and provides additional energy by increasing heart rate and blood pressure through increased stimulation by the sympathetic nervous system (SNS) and the secretion of the catecholamines, epinephrine and norepinephrine (Guyton, 1987). Activation of the hypothalamic-pituitary-adrenal cortical axis (HPAC) results in an increase in the secretion of minerocorticoids and glucocorticoids by the adrenal cortex (West, 1985). Although not measured in this study, the minerocorticoids, particularly aldosterone, can increase water and sodium retention which increases blood volume and thus blood pressure (West, 1985). Increased blood pressure helps provide more energy to the body during periods of high environmental demand (Guyton, 1987). Glucocorticoids, such as cortisol, help mobilize amino acids and fats from the cells for energy. The adrenal cortex hormones may also play a role in reducing the damage of harmful agents by reducing inflammation or fever (Guyton, 1987).

There is evidence suggesting that the type of physiological response is dependent on the nature of the environmental demand. Researchers such as Mason (1975), Frankenhaeuser (1975), Henry and Stephens (1977), and more recently Obrist (1978) and Williams (1985), have conducted research which has shown a diversity of physiological response by organisms to different kinds of environmental stressors. The body of research on physiological reactions to environmental demands does not demonstrate clear patterns of outcomes that can be expected in reaction to specific stimuli. However there are some shared perspectives on what may be taking place.

Henry and Stephens (1977), in a seminal review of human and animal stress research, concluded that elevated levels of stimulation of the SAM axis take place in conjunction with defense mechanisms of the body associated with the "fight or flight" reaction. Any stimuli perceived as threatening, challenging, or evoking fear or anger, Henry and Stephens believed would elicit an increase in SAM activation. They also suggested, based on a review of previous research, that the activation of the HPAC axis was associated with depression, events which cannot be controlled, learned helplessness, and HPAC arousal in submissive rats. Weiss and his associates (1975) have found that rats exposed to inescapable shock have increases in corticosterone, a glucocorticoid, and depressions of norepinephrine. This research is supportive of the argument that adversive stimuli which are not possible to control, and which elicit passive coping responses, will result in heightened HPAC axis stimulation, but not increased stimulation of the SAM axis.

Studies which have used human subjects have not been able to disentangle the SAM and HPAC responses to environmental demands. In general, what has been found is that events which are demanding, regardless of their negative or positive meaning, seem to heighten the level of SAM stimulation. A variety of outcomes have been observed under these situations including increases in catecholamines but not cortisol in an effortful situation that was not rated as distressing (Lundberg, 1980); increases in blood pressure, heart rate, and plasma catecholamines in response to a fast-paced cognitive task (cortisol was not measured in this study)(McCubbin, et al., 1983); increases in catecholamines in response to novelty, anticipation, and unpredictability (as reported by Frankenhaeuser, 1975); increases in blood pressure under chronic environmental stressors such as noise (Cohen, et al., 1986); and higher levels of catecholamines in residents of Three Mile Island who have been threatened by the increased risk for cancer and other diseases due to radiation exposure, when compared with control groups. (Baum & Davidson, unpublished manuscript).

Increased activity of the HPAC axis, as measured by increased levels of cortisol, has been observed in human studies in response to events rated as distressing and requiring low effort (epinephrine levels were also elevated above baseline levels)(Lundberg, 1980); low control situations which require passive but vigilant task performance (epinephrine levels were elevated above baseline levels)(Frankenhaeuser & Johansson, 1986); the novel stress associated with jumping out of a parachute (cortisol was elevated initially but returned to baseline levels over successive jumps)(Ursin, et al., 1978); and low control, competitive mental tasks (increases in catecholamines and cardiac output was also observed) (Williams, 1985).

It is still unclear whether events which are distressing, and which elicit passive coping or "helpless" responses will result in increased stimulation of the HPAC system and a depression of the SAM system in humans. Lundberg (1980) did find that cortisol levels were suppressed in low distress, effortful coping situations when compared with effortful, non-distressful situations. However, epinephrine levels were elevated in both conditions.

For the purposes of this study, elevations in the activity level of the SAM axis, as measured by blood pressure and urinary catecholamine levels, were considered an indication of physiological arousal to meet an increased environmental demand. It is evident from previous research on catecholamine and other cardiovascular responses to environmental stimuli, that environmental demands, both positive and negative in character, elicit physiological arousal of the SAM axis (Henry & Stephens, 1977; Obrist, 1978; Frankenhaeuser, 1975; Baum, et al., 1985).

Urinary cortisol measures were used as an index of HPAC axis arousal levels. In an exploratory vein, cortisol was also measured to examine the interrelationships among physiological measures and psychological measures in response to significant environmental events. The role of the HPAC axis in response to environmental demands is less clear that that of the SAM axis. We may learn more information about the stress process by characterizing the nature of events which elicit changes in cortisol levels. Mason and his associates (1976) have emphasized the importance of trying to understand the specificity of the physiological response to different stimuli:

> "Most stimuli or "stressors" studied so far evoke not just a few scattered hormonal responses, but generally elicit a broad scope of multiple, concurrent responses...." (p. 171).

There is reason to believe, based on previous research on humans, that elevations in cortisol are associated with distress (Lundberg, 1980; Frankenhaeuser & Johansson, 1986; Williams, 1985). The present research may provide additional information about the role of cortisol in response to environmental stimuli.

Psychological measures: Self-reports of mood were used to index psychological well being. The Bipolar Profile of Mood States (POMS)(Lorr & McNair, 1984) was used to assess mood change. This instrument was chosen for use in this study for several reasons. The measure consists of an adjective checklist that takes several minutes to complete. The short time required to complete the form was considered important in a six and a half month study in which participants were asked to complete a psychological self-report form three times a week.

In addition, the nature of the measure was relatively non-invasive. The crew members of the Antarctic station expressed concern, prior to the onset of the study, that any research that was to be conducted should not evaluate their clinical, psychiatric health. To do so was considered an invasion of privacy. The POMS allowed the investigator to evaluate the participants' psychological mood without intruding on their privacy.

Finally, the POMS was chosen because it has previously been validated and found reliable in a number of studies using college students, high school students, psychiatric inpatients, outpatients, and athletes (Lorr & McNair, 1984).

This instrument contains a list of adjectives and asks the subject to rate how well each adjective describes his or her mood at that point in time. Embedded within the instrument are five bipolar subscales measuring: degree of anxiety; level of hostility; degree of confidence; level of elation or depression; and energy level. The subscales for anxiety, hostility, and depression were used in the data analysis.

Data Collection

Dependent Variables

Physiological measures: Measures of blood pressure and urinary catecholamines (epinephrine and norepinephrine) were used to index the level of SAM activation.[1] Urinary cortisol measures were used as an indicator of the level of activation of the HPAC axis.

Blood pressure was measured two times a week over the six and a half month stay in Antarctica (see Table 4.2). Readings were taken between 5 p.m. and 6:30 p.m. to reduce error due to 24 hour cyclic changes in blood pressure. A sphygmomanometer was used to record blood pressure levels. Baseline measures were taken from physical examination records completed before the trip to Antarctica (see Appendix A for a copy of the forms used to record physiological data).

Urinary catecholamine and cortisol samples were taken once a week for eight of the nine subjects. The urine sample was take on one of the two days that a subject's blood pressure was measured. It also coincided with one of the days that a subject filled out a POMS mood form (see Table 4.2 for an overview of the timing of all the measures used in the research). Subjects were asked to urinate in individual containers provided in their bathroom over an eight hour period after the first morning's voiding. The urine bottle contained an anti-oxidant, sodium metabisulfite, to prevent breakdown of the catecholamines. The samples were stored on ice during the sampling period. After the eight hour collection, the urine volume was measured and a 10 ml portion was frozen at -70° C until assayed. A radioenzmatic assay was used to measure the amounts of epinephrine and norepinephrine in the urine (modified from Durrett & Ziegler, 1980). A radioimmunoassay was used to index the amounts of cortisol in the urine samples (Baxter Travenol Diagnostics, Inc.).

Psychological Self-report Measure: Subjects were asked to fill out the POMS three times a week: one time between 6 a.m. and noon; one time between noon and 6 p.m.; and one time between 6 p.m. and midnight. The instrument was administered in this fashion so that moods associated with a particular portion of the waking hours would be sampled (see Appendix A for a copy of this instrument).

Independent Variables

Weather records were collected three times a day by station personnel and included temperature, wind speed, wind direction, humidity, barometric pressure, and sky conditions. Wind speed was the measure used to indicate the harshness of the outside weather condition. Wind speed was believed to be a strong factor in environmental forces confining the residents to the built environment.

Journal entries were made by the investigator. The entries contain information about events which took place at the station. Such events included visits from individuals not wintering over,

Table 4.2 Data Collection Summary

Instrument	Schedule of Administration
Bipolar Profile of Mood States	Three times a week, one each: morning afternoon, evening.
Blood Pressure	Two times a week in the late afternoon On two of the same days POMS filled out.
Urinary Catecholamines	Once a week for the first eight waking hours. On one of the days blood pressure taken.
Urinary Cortisol	Once a week for the first eight waking hours. On one of the days blood pressure was taken, and on the same day as the urinary catecholamines were measured.
Demographic Questionnaire	Beginning of study.
Journal	Daily

parties, and external and internal incidents which may have influenced the arousal levels of individuals on station. These entries were used to index those physical, environmental and social events thought to influence stress and arousal outcomes.

Procedures

The subjects were asked to participate in a study on adaptation to long-term isolation and confinement. They were given copies of a five page overview of the study and its goals which had been used as a grant proposal for NASA. The hypotheses in the NASA proposal were deleted from the handouts given to the subjects. Ten of twelve station residents participated in the research. The data for the nine males who volunteered for the study were used in the data analysis. The investigator excluded her data from the analysis because it was felt gender differences might increase the error in the data.

Just prior to the study, subjects were asked to fill out a demographic questionnaire. During the six and a half months of the research they were asked to fill out the mood forms during certain hours three times a week. Participants had their blood pressure and 24 hour activities recorded before dinner on two of the same days they filled out mood forms. They also were asked to give an eight hour urine sample once a week. This urine sample was taken on one of the same days that the subjects' mood and blood pressure were recorded. At the end of the study the subjects were informed about the hypotheses of the study and asked for feedback on participation in the research.

Reference Notes

1. A shortcoming of these measures is that they are unable to account for the mediation of the parasympathetic nervous system (PNS). The PNS acts counter to the sympathetic nervous system, slowing the heart rate and decreasing blood pressure.

Chapter Five

Statistical Analyses and Results

The purposes of this chapter are to review the steps used in data analysis, to provide background information about the ARIMA (autoregressive, integrated, moving average) time series techniques, and to present the results of the research. This chapter discusses the choice of the ARIMA time series procedure; describes the techniques used in ARIMA time series analysis; outlines the steps taken in interrupted time series analyses and bivariate time series analyses; outlines validity threats and how different time series designs respond to those threats; describes the statistical strategies used to test the hypotheses of this study; and give the results of the study.

Choice of Statistical Technique

Time series analysis offers several advantages over cross sectional designs. It has the ability to show causal direction through temporal precedence. Time series data, by nature, provide more information with which to evaluate the relationship between dependent and independent variables (Steinberg, Catalano, & Dooley, 1981; McCleary, *et al.* 1980). In addition, time series analysis allows the investigator to use individuals as their own controls (Cook & Campbell, 1979; Glass, Willson, & Gottman, 1975; McCleary, *et al*., 1980). This last factor is important in a study such as the present one because of the difficulties of finding and coordinating comparison groups which would be equivalent in terms of subject characteristics, environments, and experiences. The capacity of time series analysis to use a single unit is also important in conditions where there is not a sample population large enough or diverse enough to drive theory-driven experimental comparison groups that would have statistical power (Glass, Willson & Gottman, 1975; Cook & Campbell, 1979; McCleary, et al. 1980).

The use of interrupted time series analysis allows one to look at the magnitude of an intervening variable's impact and whether that impact is temporary or permanent. This technique also permits the investigator to determine the immediacy of the intervening variable's influence on the dependent variables and the changing nature of its influence on the dependent variables (Glass, Willson & Gottman, 1975; Cook & Campbell, 1979; McCleary, et al. 1980; Nurius, 1983). A repeated measures ANOVA or simple t-test will not allow the investigator to see fine patterns of temporal effects. This can result in erroneous conclusions drawn from data that is too scanty to show the fuller picture that multiple time-ordered observations allow. Time series analysis is capable of evaluating not only changes in mean values but also changes in variance, slope, intercept, and seasonality (Glass, Willson & Gottman, 1975; Nurius, 1983). These types of dynamic change can lead to misrepresentations of the data if ANOVAs or t-tests are used (Glass, Willson & Gottman, 1975). For example, if an intervention changes the upward drift of the data to a downward drift, a t-test would miss this pattern and find the association between the endogenous (dependent) and exogeneous (independent) variables insignificant (Glass, Willson & Gottman, 1975).

Ordinary Least Squares Regression (OLS) can be used for time series analysis. Like ANOVA, which is an orthogonal regression technique, OLS is based on the general linear model:

(1) $$Y = b_0 + b_1X_1 + a$$

where Y represents the dependent variable; b_0 represents a constant (intercept) to be estimated; X_1 represents the independent variable; b_1 represents the slope or the expected change in the level of observation and is a coefficient to be estimated; and a represents random error. In a time series with many observations the OLS regression model would take the following form:

(2) $$Y_t = b_0 + b_1X_{1t} + b_2X_{2t} + \ldots + b_kX_{kt} + a_t$$

where the subscript t refers to the order of an observation in the series such that t = 1,2,3...n (Ostrum, 1978). The intercept b_0, can be thought of as observation t = 0 for X_{1t}, X_{2t}, ..., X_{kt} (McCleary, et al., 1980). The assumptions made by the OLS regression technique have been noted by Ostrum (1978; pg. 18, 19)) and are as follows:

"1) Linearity: the relationship between Y and X is linear

2) Nonstochastic X: $E[a_t X_t] = 0$

3) Zero mean: $E[a_t] = 0$

4) Constant variance: $E[a_t^2] = \sigma^2$

5) Nonautoregression: $E[a_t a_{t-m}] = 0$ $(m \neq 0)$

6) Normality: The error term is normally distributed."

(#6 is necessary for inferential statistics)

The assumption that there are independent error terms can not often be met in studies which take observations over time. Such dependence is referred to as serial correlation or autocorrelation (Ostrum, 1978). The autocorrelation of a series of observations allow us to determine to what degree successive observations can be predicted from previous observations. While this will not change the level and slope it will alter and bias the standard deviation so that the independent variable will appear more significant than it is. Glass and his associates (1975) argue that the dependence will tend to bias the F or t statistic. Arguments that the robustness of these statistical techniques is a remedy for dependence have missed the point since robustness does not resolve the problem of autocorrolation.

The source of dependence among the observations can be due to the degree to which a variable is predicted from previous observations, and the degree to which an observation is predicted from previous random shocks. A pseudo-Generalized Least Squares regression (GLS) approach can model first order correlations but can not respond to second order correlations or moving averages as does the ARIMA method. The use of the ARIMA (p,d,q) model responds to the association between observations. This modeling technique, developed by Box and Jenkins (1976) is based on three process components: autoregressive, integrated, and moving average components. The following discussion will describe these components in more detail.

Trend and drift are terms used to describe a move in the data in either an upward or downward direction. More specifically, trend can be defined as a systematic change in the level of a time series (McCleary *et al.*, 1980; McCain & McCleary, 1979). If a set of data did not have a trend then it could be described (McCleary, *et al.*, 1980):

(3) $$Y_t = b_0 + a_t$$

Most data has some type of trend which is represented by the inclusion of the following term:

(4) $$Y_t = b_0 + b_{1t} + a_t.$$

This systematic change is usually detrended using the OLS regression technique to estimate the trend in the data. The problem with this method of detrending the data is that it is very sensitive to both outliers and to the first and last observations. This is a *static* estimation of a trend and does not represent the fluctuations around the mean in a temporal fashion. It would be useful at this point to introduce the terms stochastic and deterministic. McCain and McCleary (1979) define deterministic components as systematic change in the data which can be best described by a linear trend. It refers to any parameters in the model that are not related to the error term (pgs. 235-236). The stochastic component refers to the unobserved error in the data which causes the data to drift in either a systematic or unsystematic fashion (McCleary, et al., 1980) One of the purposes of the ARIMA modeling technique is to uncover the structure of the systematic changes due to error so that they can be included in an equation that dynamically models the data. Unlike OLS regression techniques for estimating the trend in data, the ARIMA differencing procedures uses each of the observations to estimate the trend and/or drift in the data. This "removal" of the systematic error structure allows the investigator to arrive at unbiased standard deviations.

The integrative aspect of the ARIMA (p,d,q) method responds to the absence of stationarity in the series of observations. When a time series is stationary there is no systematic change in the increase or decrease of a time series' level over time due to error (McCain & McCleary, 1979). Differencing is used in this component of the process to remove what is called the secular trend from the time series and make the time series stationary in the homogeneous sense (McCain & McCleary, 1979, McCleary, et al., 1980). This procedure is done by (McCleary, et al., 1980):

$$(5) \qquad z_1 = Y_1 - Y_0$$
$$= (Y_0 + a_1) - Y_0 = a_1$$
$$z_2 = (Y_0 + a_1 + a_2) - (Y_0 + a_1) = a_2$$
$$\cdot$$
$$\cdot$$
$$\cdot$$
$$z_t = (Y_0 + a_1 + a_2 + \ldots . a_{t-1} + a_t)$$
$$-(Y_0 + a_1 + a_2 + \ldots . a_{t-1}) = a_t$$

where z_t represents the differenced Y_t series. Integration in the ARIMA model refers to this differencing process being additive. A trend is not removed through differencing processes but is represented differently in the equation modeling the data. If the differenced time series does not have a mean of zero then a constant O_0 must be added as a parameter. This parameter is the slope of the series. An exogeneous variable may be influencing the outcome variable if the parameter for the constant in an differenced time series is significant.

The ARIMA (0,1,0) model could be written as:

$$(6) \qquad Y_t = Y_{t-1} + \Theta_0 + a_t$$

The general notion here is that Y_t can be best predicted by the previous observation. Higher order differencing may require that observations be differenced more than once, such that the first observation is subtracted from the second observation twice in a (0,2,0) model.

In order for the data to be considered stationary both the variance and the level of the data must be taken into consideration (Glass, Willson & Gottman, 1975; McCleary, et al., 1980) Failure to do so could result in an analysis which misrepresents the data. When the variance is not stationary the data can be transformed to make the variance constant.

The autoregressive component of the ARIMA (p,d,q) technique refers to the direct relationship between lagged observations (Glass, Willson & Gottman, 1975). The first order autoregressive model (1,0,0), which is what is typically found, can be described as:

$$y_t = \phi_1 y_{t-1} + a_t. \tag{7}$$

This can be thought of as regressing the current observation on the preceding observation. The magnitude of the dependence y_t on y_{t-1} is reflected in the size of the coefficient ϕ. The closer to 1 the coefficient is, the greater the dependence. (The parameters, or the bounds of stationarity, for ϕ in a first order autoregressive model is $-1 < \phi < +1$).

In a second order autoregressive model (2,0,0), the present observation can be described as being dependent on a weighted combination of the two previous observations and can be written as:

$$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + a_t. \tag{8}$$

The bounds of stationarity for this model are:

$$-1 < \phi_2 < +1$$
$$\phi_1 + \phi_2 < +1$$
$$\phi_2 - \phi_1 < 1.$$

Typically, higher orders of autoregressive models are not found although they are theoretically possible (McCleary, et al., 1980). When they are found they can often be more parsimoniously described by using the moving average of the ARIMA (p,d,q) model.

The moving average aspect of this technique responds to random shocks and their impact on subsequent observations (McCleary, et al., 1980). These random shocks are finite in nature, in contrast to autoregressive shocks which are persistent. A first order moving average model (0,0,1) would be written as follows:

(9) $$y_t = a_t - \theta_1 a_{t-1}.$$

A second order moving average model predicts the impact on y_t from the two preceeding random shocks, a_{t-1} and a_{t-2}. The parameter constraints, or bounds of invertibility are the same as the bounds of stationarity for both the first order and second order autoregressive models.

It is possible to have ARIMA models which are mixed, however it is unlikely to have models which have both autoregressive and moving average components because of the underlying relationship between these two structural parameters (McCleary, et al., 1980). A moving average model could be defined as an autoregressive component because of this element of redundancy.

Seasonal Parameters

ARIMA techniques allow one to model seasonal trends through seasonal structural parameters analogous to the same three structural components discussed above. A seasonal model would be specified ARIMA (p,d,q) $(P,D,Q)_s$ where the P refers to the number of seasonal autoregressive lags; D refers to how many times a set of time-ordered observations must be seasonally differenced; Q refers to the number of seasonal moving average terms; and s refers to the length of the cycle. Unlike the non-seasonal models, the seasonal models are multiplicative, that is the regular and seasonal ARIMA structures are multiplied by each other. The data produced in this study did not require the incorporation of seasonal parameters as it was possible to model any cyclical patterns, such as monthly cycles, through the regular ARIMA modeling technique. The seasonal parameters are used to model data that is collected over several years. The brevity of the this study eliminated the need for seasonal parameters.

Model Development

The ARIMA approach follows three steps in developing a model of data: identification of the parameters; estimations of those parameters; and diagnosis. The steps involved in modeling the data will be reviewed briefly.

The ARIMA time series analysis uses the autocorrelation function (ACF) and the partial autocorrelation function (PACF) to identify the parameters of a model (McCain & McCleary, 1979; and McCleary, et al., 1980). More specifically, $(ACF)_k$ gives the correlation between the time series (lag-0) and its k^{th} lag. The $(PACF)_k$ gives the correlation of observations k^{th} lags apart when the observations between those lags are partialled out. Each of the structural components has a signature which can be identified using the combination of the ACF and PACF. McCain and McCleary (1979; pg.

249), suggest that the first step of identification is to see if the ACF drops sharply, to determine whether the data is stationary. If it does not drop sharply, then the data is nonstationary and steps should be taken to make it stationary. In general, an autoregressive model should have a decaying ACF, and a PACF with p nonzero spikes in the first p lags (p refers to the order of the autoregressive parameter in the model). Moving averages, in contrast, are identified by a decaying PACF and ACF's that have q nonzero spikes in the first q lags (q refers to the order of the moving average parameter in the model). An ARIMA model with both autoregressive and moving average terms will have decay in both the ACF and the PACF (McCleary, et al., 1980; pg. 78). This is a very simplified overview of this process and it should be understood that the patterns in the ACF and PACF may not be this clean.

Estimation is the second step in the process. McCleary and his associates (1980) identify two important parts of this process: the parameters for the autoregressive and/or moving average should be significant, and the moving average and autoregressive parameter estimations have to lie within the bounds of stationarity and invertibility. If any of these parameters is not significant then it should be dropped from the model. If one or more of these parameters does not fit within the bounds described then the model should be rejected and be re-identified for a better fit.

If the model passes the estimation stage, then it can be diagnosed. The regular diagnosis procedure looks at the residuals of the model. These residuals must meet two requirements: they must be independent at the first and second lags and they must be distributed randomly with a mean zero and and constant variance [also called white noise process] (Box & Jenkins, 1976). It is expected that over the course of the observations there may be several data points that will be significantly different from zero. To determine whether these random spikes violate the assumptions of the white noise process, a Q statistic is used (a chi-square goodness-of-fit test for the autocorrelation function). If this statistic is significant, then the model is inadequate and must be re-identified (McCleary, et al., 1980).

Interrupted Time Series Analysis

The weeks that festivities took place at the station, and the final two weeks of the winter when the summer crew arrived, represent intervening variables which were modeled as multiple interrupted time series. Variables which are considered intervening variables in interrupted time series analyses are treated as binary variables which designate the presence or absence of that variable's influence. When, as in this study, the intervening variables are expected to have an immediate, temporary influence on the dependent variables, that are hypothesized to last the same length of time that the intervening variable is present, those binary intervening variables are introduced into each of the models of the dependent variables as a transfer function of the following form (from McCleary, et al., 1980):

(10) $$Y_t = \omega_o I_t + N_t$$

where:

I_t = 1 during the event

= 0 before and after the event.

A t statistic is then used to estimate whether those time periods during which the independent variable was present was significantly different from those time periods during which the the independent variable was absent. Those intervening variables which are not significant for a particular dependent variable are dropped from that outcome variable's model.

Bivariate Time Series Analysis

The change in wind speed over the course of the winter was considered an independent time series variable that could have an impact on the outcome variables. Wind speed was suspected of influencing the inhabitants ability to spend time outside, away from the physical confinement of the built environment. The transfer functions for the multivariate time series analysis are similar to those used in the interrupted time series variable transfer function (from McCleary, et al., 1980):

(11) $$Y_t = \omega_o X_t + N_t$$

The steps in conducting a bivariate time series analysis start with making sure that both the independent variable and the outcome variables are stationary. The influence of any intervening variable or variables are removed from the outcome series through transfer function models of those intervening variables. The resulting residuals of the modeled outcome measures are used in the whitening and cross correlation function (CCF) stages of the bivariate time series analysis. The independent time series variable is modeled for its ARMA parameters. Those parameters are then used in a transfer function model to filter the dependent series, this is called prewhitening. The white noise independent time series variable and the whitened residuals of the outcome measures are then checked to determine the CCF between the causal variable and the dependent measures. If there is a significant correlation between the independent measure and the dependent variables in the causal direction, and time ordered relationship hypothesized, then the independent variable can be included in the model of the dependent variable and tested for its significance in predicting the outcome values.

The Final Time Series Model

The final model to be estimated and diagnosed for each dependent measure could include binary intervening variables, an independent time series variable, and ARIMA parameters. Such a model could take the following form:

$$(12)\quad (1 - \phi B)Y_t = c + \omega_{oa}I_{ta} + \omega_{ob}I_{tb} + \omega_{oc}X_t + N_t$$

where $(1-\phi B)$ is a first order autoregressive parameter; c is a constant; $\omega_{oa}I_{ta}$ and $\omega_{ob}I_{tb}$ are each intervening variables; $\omega_{oc}X_t$ is the independent time series variable; and N_t is the noise component of the model.

Threats to Time Series Analysis

There are a number of threats to time series analyses. Threats to internal validity include mortality and maturation (Glass, Willson & Gottman, 1975; Cook & Campbell, 1979). Mortality was not a problem in this study as none of the subjects dropped out of the project. The relatively short duration of this study reduces the threat of change due to maturation (Glass, Willson & Gottman, 1975; Cook & Campbell, 1979).

Rival hypotheses are a major threat to time series studies. Catalano and his associates (1983) have outlined steps that can be taken to reduce this type of problem. They suggest that hypotheses should be written in a manner that eliminates as many alternative explanations of the data as possible. Their first suggestion is that hypotheses be structured a priori to the analysis of the data. The a priori formulation of the hypotheses should indicate temporal precedence, direction of the association (positive or negative), and the lag time that can be anticipated between the change in the predictor variables and the dependent variables.

The second recommendation that Catalano et al. (1985) make is that three dichotomous dimensions of rival third variables should be considered when constructing hypotheses: the regular-irregular dimensions, the accessible-inaccessible dimension, and the local-general dimension. Regular variables are systematic variables whose behavior can be described as a trend or cycle. An example of a regular variable which may influence stress in this study is day length. Third variables which are irregular have random variation and their expected value is best predicted by previous mean levels. In an ICE an irregular third variable may be the fluctuating ability of the station personnel to contact the United States on the HAMM radio. The dimension of accessibility-inaccessibility refers to whether a third variable is suspected and whether it can be measured. An inaccessible variable can either be suspected but not measured, or unsuspected. General third variables have effects which are not localized but influence many populations. Local third variables have confounding influences only in the geographical area or on the group of individuals under consideration. Rival hypotheses can be of a nature that combine any permutation of these three dimensions. For example, world news may have been an unmeasured, general third variable that had an impact on the stress levels of all the ICE communities in Antarctica. A local third variable which was not measured in this study but which may have influenced the outcome measures was the changing nature of the demands placed on the residents of the Antarctic station by outside supervisors.

A number of steps were taken to meet the threats to the time series analyses conducted in this study. The hypotheses used in the research were constructed according to the guidelines developed by Catalano and his associates (1985). In addition, the non-random, cyclical nature of day length and other regular variables were controlled for by using the integrative aspect of the ARIMA time series techniques. The effects of these regular variables can be removed regardless of whether they are accessible or inaccessible, local or general in quality (Catalano, Dooley & Jackson, 1985).

All of the accessible irregular variables that were hypothesized to play a role in the outcome variables were included in the analyses. Because the research focused on social and physical factors in the environment that might influence stress outcomes, none of the accessible irregular variables were considered "third variables".

Confounding factors which may be inaccessible and irregular are best controlled by conducting studies in other settings which are believed to share most or all of the same irregular, inaccessible third variables as the original study site (Catalano, 1981; Catalano, Dooley & Jackson, 1985; Catalano & Serxner, 1987). It is possible that there are inaccessible local and general variables which may have influenced the dependent variables in this study. However, the very controlled and "laboratory-like" environment of the Antarctic research station limits that possibility. The inhabitants of these ICE's are exposed to fewer extraneous factors than the average person in a setting that is not isolated and confined. If inaccessible variables are confounding factors in this study, their role must wait to be specified until this research is replicated in a comparison community.

Statistical Procedures

To place the results of this research in context, the steps taken in the interrupted and bivariate time series analyses will be briefly discussed.

The time series were first checked to determine whether they were stationary. Box-Cox transformations (1964) were utilized to assess whether the variance was constant over the time series processes, and to determine the best transformation of those data whose variance was not stationary. The ACF's of the residuals for each variable were checked to see if the series needed to be differenced to remove the trend or drift in the data. Any trends in the data were hypothesized to be an outcome of the cumulative costs of adapting to the Antarctic setting. The outcome variable "anxiety" was the only time series for which the differencing parameter was significant. The differencing parameter was retained in the ARIMA model of the variable "anxiety" during the estimation and diagnosis of possible autoregressive and moving average parameters. There were no significant autogressive or moving average parameters for the "anxiety" time series. Wind speed, festivities, and the summer crew exchange were not significantly associated with the anxiety scores. A regression analysis of the relationship between time in Antarctica and anxiety scores was conducted after it was determined that there were no significant autoregressive or moving average parameters, and that the independent variables were not predictive of anxiety scores. The r^2 for the regression analysis was large, .7386 (see results and Table 5.6). A Durbin-Watson test to check for first order autocorrelation was conducted to insure that there was no correlation among the residuals. Although the original ARIMA modeling of the anxiety time series indicated there was no autocorrelation, the Durbin-Watson test was carried out to double check the results of the ARIMA modeling.

Initial estimations and diagnoses of the autoregressive and moving average parameters (ARMA parameters) were made for each of the time series, before the intervening variables and the independent time series variable were introduced into the models for each outcome variable. These initial models of the dependent variables were developed as a reference to the underlying structure of these time series.

The intervening variables were then incorporated into each of the outcome time series models. All of the hypothesized intervening variables were introduced simultaneously into each dependent variable's model. The autoregressive and moving average parameters were then re-estimated and diagnosed. For each dependent variable time series, the intervening variables which were significant, and the ARMA parameters which were statistically significant were retained in the model.

The stationary, independent time series variable, wind speed, was examined to determine possible autoregressive and moving average parameters. There were no significant ARMA parameters for wind speed. Filtering of the dependent variables by the ARMA parameters of the variable wind speed was not required because there were no significant ARMA parameters.

The dependent outcome measures were then re-modeled with only the significant intervening variables included in the model, and any differencing parameters that were significant (no ARMA parameters). These models were constructed to insure that the dependent time series were stationary and to partial out the influence of the significant intervening variables on the outcome measures. The residuals of the modeled dependent variables were then checked for their CCF with the independent variable time series, wind speed. The hypotheses established that the relationship between wind speed and the outcome measures should be synchronous. Theoretically, it is impossible for any of the outcome measures to cause a change in the wind speed, so it was only necessary to consider the influence wind speed might have had on the outcome measures.

Wind speed was incorporated into the model of each of the outcome measures with which it had a significant CCF at the zero time lag (i.e., they moved synchronously with wind). A significant CCF was one in which the correlation was greater than 2 standard errors. At this stage in the analysis of the data, each of the outcome time series had included in its model those binary intervening variables, and the independent time series variable that were significantly associated with the outcome measure. The one exception to this was the outcome measure, norepinephrine. Although wind speed did not have a significant CCF with norepinephrine, wind speed was incorporated into the model of norepinephrine because of the strong correlation between the binary variable, festivities, and wind speed within the model of norepinephrine.

The ARMA parameters for each of the outcome time series models were then re-estimated and diagnosed after the significant binary intervening variables, and the independent time series variable were incorporated in the model. The final model for each outcome variable is presented below in the results section of the chapter.

Results

Presentation of Data

The means and the standard deviations for each of the time series used in this study are presented in Tables 5.1-5.8. These tables also provide the significant ARIMA parameters and constant of the model for each time series. The independent variables that proved significant for each outcome variable are presented in these tables. The coefficients for the significant independent variables are included in the tables, as well as those coefficients' standard errors and t values. Tables 5.9-5.16 present the autocorrelation and partial autocorrelation function for each of the outcome variables in the original data before these data were modeled and the influence of the independent variables were added to the models. Tables 5.9-5.16 also include the autocorrelation and partial autocorrelation functions for the final models chosen for each of the outcome variables. ARIMA parameters chosen for these outcome variable models were effective in both reducing the Q statistic (a chi-square goodness-of-fit test for the autocorrelation function) and were significant at the .1 level. The decision to include an ARIMA parameter was a balance of the parameter's ability to both have a significant t value and reduce the Q statistic. For this reason parameters which were significant at the .1 level and which also reduced the Q statistic were considered adequate for the final ARIMA models chosen (McCleary, et al., 1980).

The influence of each of the independent variables will be discussed below.

Chronic Environmental Factors

Length of stay in an isolated and confined environment. The cumulative costs of coping hypothesis predicted that the isolated and confined qualities of the Antarctic setting during the winter months would require increased efforts by the inhabitants to cope and adapt to the stressful setting. The cost of adapting over time was expected to result in increased physiological arousal over time as measured by blood pressure, norepinephrine, epinephrine, and cortisol. Self-reports of anxiety and hostility were also expected to increase over the tenure of the stay in Antarctica. The dynamics model of chronic stress and the habituation/adaptation model of chronic stress predicted that there would be no significant increases in physiological arousal. Increases in negative mood reports were not expected under this alternative hypothesis.

Self-reports of anxiety did increase over the six and a half month winter period (Table 5.6). The correlation between time spent in Antarctica and anxiety was .859. The amount of the variance of anxiety explained by the time in Antarctica was 73.8%. A Durbin-Watson d statistic test was run to insure that there was no significant autocorrelation. The d statistic is based on theoretical distribution to determine if the autocorrelations observed are random in nature. If the d statistic is greater than the upper limits level for the significance levels of d (d_U), then the null hypothesis that there is no significant level of autocorrelation can be accepted. The d statistic calculated (1.588) was greater than the d_U (1.47) and so the null hypothesis that the correlation between the residuals were equal to zero was accepted. There was no significant increase in hostility or depression over the course of the winter. No statistically significant increases were observed in any of the physiological measures of arousal.

Physical confinement due to strong winds. Strong winds were considered indicative of harsh weather conditions which kept the participants in the study confined inside the buildings at Palmer Station. It was expected that increases in wind speed would be associated with increases in blood pressure, catecholamines, cortisol, and self-reports of hostility and anxiety.

It was hypothesized that if wind had an influence on the outcome variables it would be synchronous, and significant correlations would be found at the zero time lag. Significant CCF's at the zero time lag were found between wind and: depression (.40), epinephrine (.40), and systolic blood pressure (.44). The negative or positive sign of the CCF can not be interpreted. Wind speed was incorporated into the models for these outcome variables. Wind speed was also included as a predictor variable for norepinephrine. As discussed earlier in the statistical procedures section of this chapter, there was a strong correlation between wind speed and festivities within the time series model of norepinephrine. The strong correlation of wind speed with festivities indicated that the variance partialed out of norepinephrine by festivities during the calculation of the CCF was too conservative an estimation of wind speed's influence on norepinephrine outcome measures.

All of the outcomes were contrary to expectation. Epinephrine and norepinephrine significantly decreased during high wind periods, and increased during periods of low wind speed. A two-tailed t-test was used to measure the significance of the relationship between the catecholamines and wind speed because the results were counter to the direction of the hypotheses. The epinephrine results were $t(25) = 2.38$, $p < .05$. The relationship between norepinephrine and wind speed were $t(25) = 2.36$, $p < .05$. Systolic blood pressure levels were also negatively correlated with wind speed and approached statistical significance, $t(25) = 1.95$, $p < .1$. Depression levels had a positive correlations with wind speed which was significant, $t(26) = 2.18$, $p < .05$. Self-reports of depression increased when the wind speed increased, and decreased when the wind speed decreased. There were no significant relationships between wind speed and cortisol, hostility, or anxiety.

Acute Environmental Factors

Festivities. Those weeks in which festivities took place were expected to be associated with increases in catecholamines and blood pressure. These time periods were also expected to be associated with decreases in self-reports of hostility, anxiety, and depression. No significant increases were expected for cortisol during the festivities. Epinephrine levels were significantly higher during the weeks in which parties took place, $t(25) = 1.77$, $p < .05$ (one-tailed t-test). However the increase in norepinephrine during the festivities weeks only approached significance, $t(25) = 1.68$, $p < .1$ (one-tailed t-test). Blood pressure, cortisol, and self-reports of mood for these festivities weeks did not differ from those weeks in which festivities did not take place.

Summer crew exchange. At the end of the winter the crew for the following year arrived at the station. The time during the overlap between the old crew and the new crew was expected to be associated with increases in all of the physiological measures. Self-reports of hostility and anxiety were also expected to be elevated. Blood pressure levels were the only outcome variables that were significantly elevated during this time period. Systolic blood pressure levels were higher, $t(25) = 3.55$, $p < .005$ (one-tailed t-test), as were diastolic blood pressure levels, $t(26) = 2.65$, $p < .01$ (one-tailed t-test).

Table 5.1 Epinephrine Results

Mean 886.822 ng/hour. Standard deviation 199.301 ng/hour.

The best ARIMA model is (0,0,0)

Significant parameters and independent variables incorporated in the model:

Parameter	Coefficient	S.E.	t value	df
Variable				
Wind speed	- .0271	.0114	2.38*	25
Festivities	.0421	.0238	1.77**	25
Constant	3.7873	.0387		

* $p < .05$, two-tailed test.
** $p < .05$, one-tailed test.

Table 5.2 Norepinephrine Results

Mean: 3593.619 ng/hour. Standard deviation: 888.217 ng/hour.

The best ARIMA model is (0,0,0)

Significant parameters and independent variables incorporated in the model:

Parameter	Coefficient	S.E.	t value	df
Variable				
Wind speed	-15.0149	6.3497	2.36*	25
Festivities	22.2753	13.2819	1.68+	25
Constant	268.8861	21.5847		

* $p < .05$, two-tailed.
\+ $p < .1$, one-tailed.

Table 5.3 Cortisol Results

Mean: 597.036 ng/hour. Standard deviation: 132.761 ng/hour.

The best ARIMA model is (1,0,0)

Significant parameters and independent variables incorporated in the model:

Parameter	Coefficient	S.E.	t value	df
First order autoregressive parameter	-.2744	.1757	1.56+	26
Constant	3.4210	.8295		

+ $p < .1$.

Table 5.4 Systolic Blood Pressure Results

Mean: 121.43 mmHg. Standard deviation: 2.452 mmHg.

The best ARIMA model is (0,0,0)

Significant parameters and independent variables incorporated in the model:

Parameter	Coefficient	S.E.	t value	df
Variable				
Wind speed	- .0290	.01497	1.95+	25
Summer crew exchange	.2276	.0642	3.55***	25
Constant	10.8118	.0486		

*** $p < .005$, one-tailed.
+ $p < .1$, two-tailed.

Table 5.5 Diastolic Blood Pressure Results

Mean: 78.21 mmHg. Standard deviation: 2.43 mmHg.

The best ARIMA model is (0,0,0)

Significant parameters and independent variables incorporated in the model:

Parameter	Coefficient	S.E.	t value	df
Variable				
Summer crew exchange	.0292	.0110	2.65++	26
Constant	1.8909	.0021		

++ $p < .025$, one-tailed.

Table 5.6 Anxiety Self-Report Results

Mean: 23.406. Standard deviation: 1.429.

Regression Analysis

Predictor	Coefficient	S.E.
Intercept	2.7609	.0076
Weeks in Antarctica	- .0039	.00046

$r^2 = .7386$ $r = .859$

Durbin-Watson test for autocorrelation (1,26) d = 1.588
$d_L = 1.32$, $d_U = 1.47$ at the .05 significance level.
Since $d > d_U$, then accept null hypothesis that first order autocorrelation = 0.

Table 5.7 Hostility Self-Report Results

Mean: 27.394. Standard deviation: .941.

The best ARIMA model is (0,0,0)

Significant parameters and independent variables incorporated in the model:

Parameter	Coefficient	S.E.	t value	df
First order moving average	- .3416	.1748	1.95+	26
Constant	1.4377	.0034		

+ $p < .1$, two-tailed test.

Table 5.8 Depression Self-Report Results

Mean: 22.499. Standard deviation: 1.399.

The best ARIMA model is (0,0,1)

Significant parameters and independent variables incorporated in the model:

Parameter	Coefficient	S.E.	t value	df
First order moving average	- .3698	.1765	2.10*	25
Variable				
Wind speed	- .0114	.0052	2.18*	25
Constant	1.3892	.0174		

* $p < .05$, two-tailed test.

Table 5.9 Autocorrelations and Partial Autocorrelations for Epinephrine

Original data:

Autocorrelations:

1-5 lags:	.31	.02	- .02	.08	.14
Std. E.:	.19	.21	.21	.21	.21
Q stat.	2.90	2.90	3.10	3.80	4.00

Partial Autocorrelations:

1-5 lags:	.31	- .08	.00	.10	.09

ARIMA modeled data:

Autocorrelations:

1-5 lags:	- .01	- .21	- .09	.03	.10
Std. E.:	.19	.19	.20	.20	.20
Q stat.	.00	1.40	1.70	1.70	2.10

Partial Autocorrelations:

1-5 lags:	- .01	- .21	- .10	- .02	.07

Table 5.10 Autocorrelations and Partial Autocorrelations for Norepinephrine

Original data:

Autocorrelations:

1-5 lags:	.24	.12	.12	.22	.16
Std. E.:	.19	.20	.20	.20	.21
Q stat.	1.80	2.20	2.70	4.40	5.30

Partial Autocorrelations:

1-5 lags:	.24	.06	.08	.18	.07

ARIMA modeled data:

Autocorrelations:

1-5 lags:	- .02	- .06	.08	.12	.05
Std. E.:	.19	.19	.19	.19	.19
Q stat.	.00	.10	.40	.90	1.00

Partial Autocorrelations:

1-5 lags:	- .02	- .06	.08	.12	.07

Table 5.11 Autocorrelations and Partial Autocorrelations for Cortisol

Original data:

Autocorrelations:

1-5 lags:	.27	.18	.13	- .08	- .17
Std. E.:	.19	.20	.21	.21	.21
Q stat.	2.30	3.40	4.00	4.20	5.20

Partial Autocorrelations:

1-5 lags:	.27	.12	.06	- .16	- .15

ARIMA modeled data:

Autocorrelations:

1-5 lags:	.02	.10	.11	- .13	- .15
Std. E.:	.19	.19	.19	.20	.20
Q stat.	.00	.30	.70	1.30	2.10

Partial Autocorrelations:

1-5 lags:	.02	.10	.10	- .15	- .17

Table 5.12 Autocorrelations and Partial Autocorrelations for Systolic Blood Pressure

Original data:

Autocorrelations:

1-5 lags:	- .01	.23	.10	- .08	- .13
Std. E.:	.19	.19	.20	.20	.20
Q stat.	.00	1.70	2.00	2.20	2.80

Partial Autocorrelations:

1-5 lags:	- .01	.23	.11	- .14	- .20

ARIMA modeled data:

Autocorrelations:

1-5 lags:	- .10	.09	.03	- .02	- .09
Std. E.:	.19	.19	.19	.19	.19
Q stat.	.30	.60	.60	.60	.90

Partial Autocorrelations:

1-5 lags:	- .10	.08	.05	- .02	- .10

Table 5.13 Autocorrelations and Partial Autocorrelations for Diastolic Blood Pressure

Original data:

Autocorrelations:

1-5 lags:	.12	- .10	- .05	- .01	.15
Std. E.:	.19	.19	.19	.19	.20
Q stat.	.40	.80	.90	.90	1.70

Partial Autocorrelations:

1-5 lags:	.12	- .12	- .02	- .02	.16

ARIMA modeled data:

Autocorrelations:

1-5 lags:	.03	- .15	- .10	.01	.19
Std. E.:	.19	.19	.19	.20	.20
Q stat.	.00	.70	1.10	1.10	2.40

Partial Autocorrelations:

1-5 lags:	.03	- .15	- .10	- .01	.16

Table 5.14 Autocorrelations and Partial Autocorrelations for Anxiety

Original data:

Autocorrelations:

1-5 lags:	.76	.59	.48	.40	.33
Std. E.:	.19	.27	.31	.31	.35
Q stat.	18.50	30.20	38.30	43.90	47.90

Partial Autocorrelations:

1-5 lags:	.76	.05	.04	.01	.01

ARIMA modeled data:

Autocorrelations:

1-5 lags:	.18	- .20	- .21	- .25	- .17
Std. E.:	.19	.19	.20	.21	.22
Q stat.	1.00	2.30	3.80	6.00	7.10

Partial Autocorrelations:

1-5 lags:	.18	- .24	- .14	- .25	- .20

Table 5.15 Autocorrelations and Partial Autocorrelations for Hostility

Original data:

Autocorrelations:

1-5 lags:	.33	.11	.24	.25	.23
Std. E.:	.19	.20	.21	.22	.23
Q stat.	3.50	3.90	5.90	8.20	10.10

Partial Autocorrelations:

1-5 lags:	.33	.01	.22	.13	.13

ARIMA modeled data:

Autocorrelations:

1-5 lags:	.01	.06	.17	.17	.11
Std. E.:	.19	.19	.19	.19	.20
Q stat.	.00	.10	1.10	2.10	2.60

Partial Autocorrelations:

1-5 lags:	.01	.06	.17	.17	.10

Table 5.16 Autocorrelations and Partial Autocorrelations for Depression

Original data:

Autocorrelations:

1-5 lags:	.35	.05	- .03	.13	.08
Std. E.:	.19	.21	.21	.21	.21
Q stat.	4.00	4.00	4.10	4.70	5.00

Partial Autocorrelations:

1-5 lags:	.35	- .09	- .02	.18	- .03

ARIMA modeled data:

Autocorrelations:

1-5 lags:	.02	.05	.03	.02	- .11
Std. E.:	.19	.19	.19	.19	.19
Q stat.	.00	.10	.10	.10	.50

Partial Autocorrelations:

1-5 lags:	.02	.05	.03	.01	- .11

Chapter Six

Discussion

The present study had two foci. One purpose of the research was to address shortcomings of previous ICE research by using frequent measures of psychological mood and physiological arousal to develop a sequential model of person-environment transactions in an Antarctic ICE. The second purpose of the study was to examine the person-environment transactions taking place during an austral winter to better understand chronic stress processes.

The length of stay in the ICE was not associated with increases in the measures of blood pressure or urinary measures of epinephrine, norepinephrine, and cortisol. There were no linear increases in self-reports of depression or hostility over the length of the stay in the ICE. These results support the habituation/adaptation model and dynamics model hypothesis. However, there was a linear increase in self-reports of anxiety over the course of the winter months in Antarctica. The increase in self-reports of anxiety was consistent with the cumulative costs of coping hypothesis. The harsh weather was associated with significant changes in the outcome variables but not in the direction predicted. Self-reports of depression increased when the wind speed increased, while systolic blood pressure levels and urinary measures of epinephrine and norepinephrine decreased. As hypothesized, there was a significant increase in urinary epinephrine during those time periods at the Antarctic station when festivities took place. However, norepinephrine levels increased only marginally during these time periods, and there were no significant increases in blood pressure or self-reports of positive moods. The arrival of the new crew at the end of the winter was associated with significant increases in blood pressure as was predicted. The hypothesis that the arrival of the summer crew would be associated with increases in catecholamines, cortisol and self-reports of anxiety and hostility was not confirmed.

The outcomes of this research support the interpretation that the chronic stress process is dynamic in nature. The isolated and confined environment of Antarctica is not a static source of stress, but instead a dynamic environment in which both acute and chronic forces impinge upon the individual. Changes in the outcome measures resulted from a compilation of effects including the chronic characteristics of the Antarctic station as well as acute events. What an individual experiences in a setting is not a static demand from the environment. Physical and social elements of environments continually modulate. As the environment shifts, the demands placed on the individual change. The demands on the individual, in turn alter physiological arousal levels and psychological mood.

In this chapter I will discuss the implications of the research results for theories of the chronic stress process. The dynamic interplay of acute and chronic factors in the Antarctic setting indicate that models of the chronic stress process need to account for not only the static environmental demands of a setting but also those elements of the environment that change. The cumulative costs of adaptation and habituation/adaptation models of chronic stress will be examined in light of the research findings of this study. The argument is made that stress should be considered a dynamic process that at any point in time is composed of a compilation of environmental forces placing changing demands on an organism. It is not enough to know what kinds of stress responses are caused by the static demands of an environmental stressor. The chronic stress process must be considered a dynamic environment-person process that is best understood by examining changing environmental demands and the subsequent responses of individuals over time.

Theories of Chronic Stress and Chronic Stress during an Antarctic Winter

Predictable Chronic Stressors

One of the purposes of this study was to compare the dynamics model of chronic stress with the cumulative costs of adaptation model of chronic stress and the habituation/adaptation model of chronic stress. The cumulative cost of coping model of chronic stress suggests that responses to ongoing stressors may result in a continuous effort by the body to meet large environmental demands. The habituation/adaptation model of chronic stress theorizes that over time individuals will habituate to environmental demands. The dynamics model of chronic stress predicts that individuals can adapt to predictable, ongoing environmental stimuli.

The synergistic, low stimulus qualities of the Antarctic ICE were considered a static environmental backdrop against which other physical and social variables changed. The cost of coping model would predict the efforts of the organism to meet the high environmental demands of a chronic stressor, such as an Antarctic research station during the winter, would result in increased physiological arousal due to an upward shift in the body's homeostatic level of arousal. Increases in self-reports of hostility and anxiety would also be expected as an outcome of coping with a physically arousing stressor according to this model. However, self-reports of anxiety were the only outcome measures that increased over the course of the winter.

In general, the study participants were able to habituate to the predictable environmental demands of the Antarctic setting. While the study participants' self-reports of anxiety did increase over the course of the winter, no other outcome measures changed in a linear trend over the time in Antarctica. In addition, the change in anxiety scores over the course of the winter still fell within one standard deviation of population normative scores on the POMS (Lorr & McNair, 1984). Both the habituation/adaptation model of chronic stress and the dynamics model of chronic stress would predict that the study participants would be able to adapt to the low stimulus setting of Antarctica. According to Wohlwill (1974), this adaptational process takes place because individuals shift their frame of reference in response to the level of environmental stimuli present in the setting. Continuous exposure to a predictable level of environmental stimuli results in that stimulus level becoming the new normative level of environmental demands for the individual. Outcome measures should not increase over time if the individual is able to habituate to the level of environmental stimuli present in a setting. Alternatively, if one is exposed to a shift in the level of stimuli present in a setting, an initial change in arousal levels and psychological mood may be observed with a subsequent return to baseline levels. Due to logistical constraints associated with this research the collection of data did not begin until the second week of the winter. This meant that any initial change in the outcome measures were missed. It would be useful in future studies testing the habituation/adaptation model of chronic stress to determine if initial exposure to a setting with a different level of environmental demand causes a short term physiological and psychological response which eventually returns to baseline.

The outcomes of the research suggest that continuous exposure to the increasingly predictable, low stimulus, ambient environment of the Antarctic ICE may have caused the study participants to shift their frame of reference for normative background environmental demands. The lack of change in physiological outcomes and self-reports of hostility and depression over the winter reflect this shift in perspective on what constitutes normative environmental demands.

This research is consistent with previous studies that have shown that individuals can adapt to changes in the level of stimuli present in their setting. Haggard, et al. (1970) found that Norwegians living in isolation showed less stress when exposed to low levels of sensory input than did residents of the city of Oslo. Likewise, in a study by Evans and his associates (1981), long-term residents of the Los Angeles air basin area were less likely to rate pictures of low level smog scenes as having smog than did recent migrants to Los Angeles. The recent migrants in this study came from low smog settings.

Unpredictable Chronic Stressors

When a component of the environment is not constant in its demands, and when it is unpredictable, individuals may not be able to habituate to that environmental factor. Physical confinement to the buildings in Antarctica was dependent on weather conditions. The harshness of the weather was indicated by wind speed. It was hypothesized that being confined to the buildings due to high winds would cause heightened arousal of the SAM axis as indicated by increases in catecholamine and blood pressure levels. People were expected to also become more hostile and anxious during these periods of high winds and physical confinement.

Contrary to expectations, the bivariate time series analysis indicated that as the winds increased catecholamine and systolic blood pressure levels decreased and self-reports of depression increased. While these findings were contrary to expectation what these results suggest is physical confinement had a physiologically and psychologically depressing influence on the study participants.[1] Rather than causing anxiety and physiological arousal, being confined to the indoors may have had a different kind of negative impact. One interpretation of the lower levels of catecholamines, systolic blood pressure and increases in reports of psychological depression during periods of high wind could be that people became more withdrawn when they were confined to the buildings rather than building up excess anxiety and hostility.

The fluctuations in the wind consistently resulted in concomitant changes in physiological and psychological outcomes. The study participants were unable to habituate to change in the weather conditions. The weather was a chronic, background element of the environment that was both ubiquitous and constantly changing. Its nature and impact were different than the synergistic qualities of the Antarctic setting. The station, its buildings and geographical characteristics remained constant. The demands that the low stimulus, synergistic setting made were relatively constant. It was the other factors in the setting that changed. The inhabitants of the stations appeared unable to habituate to the unpredictable quality of the weather and the associated changes in the degree of confinement the weather imposed. Over the course of the whole winter, as the weather fluctuated, so did the outcome measures. This is in contrast to the low stimulus, synergistic qualities of the Antarctic setting which remained largely static in stimulus levels. The change in the weather influenced the degree of physical confinement the study participants experienced. This change in physical confinement was an unpredictable element of the setting.

This unpredictable change in the level of environmental demand was associated with concommitant changes in the outcome measures.

The Dynamic Nature of the Chronic Stress Process

The synchronous change in the outcome measures in response to weather fluctuations over the course of the whole winter is an indication that chronic stress processes are dynamic. The stress process is not only dynamic because of the fluctuations in environmental demands of one factor in the setting. It is also dynamic because of the changing profile of acute and chronic environmental components that make up every setting. The cumulative costs of adaptation model and the habituation/adaptation model of chronic stress have primarily been used in previous research to discuss static environmental demands on the organism. For example, Cohen and his associates (1986) treated the long-term effects of the uncontrollable and unpredictable noise pollution associated with the flight pattern at Los Angeles International Airport as a static, unchanging demand. Although this study considered contextual factors associated with the stress experienced by the student participants of the study, the dimension of change in the profile of acute and chronic stressors in the setting was not treated.

The outcomes of this study suggest that changes in the outcome measures were a compilation of effects including the chronic environmental factors as well as acute events. What the study participants experienced during this Antarctic winter was not just a static environmental demand. Nor was the experience in this chronically stressful setting simply an accumulative stress process that could be adequately indexed by taking measures before and after the experience in Antarctica. Instead the findings reveal a highly dynamic process of chronic stress.

None of the environmental forces at play in the Antarctic ICE operated alone. There was an overlay of chronic conditions and acute events at any one point in time. Individuals responded to the changing combination of these chronic and acute environmental factors. For example, high winds were associated with decreases in catecholamines and systolic blood pressure, and increases in self-reports of depression. However, intervening events changed these patterns of outcomes. When parties or social events took place epinephrine levels were significantly elevated and norepinephrine levels were marginally above the average for the entire winter. These special occasions allowed people to interact differently, stepping away from the day-to-day relations and putting forth a more playful side. These festivities took place against the backdrop of fluctuating environmental demands due to changes in weather, and the more static, predictable demands of the ambient Antarctic setting. When the influence of the festivities were partialed out, the winds had a physiologically and psychologically depressing influence on the study participants (see the discussion of statistical analysis procedures in chapter 5).

The influence of multiple environmental factors in this study were additive. In contrast to the impact of high winds alone, blood pressure levels and reports of depression were not lower than average during those weeks in which both special events and high winds occurred. The observed pattern of elevated catecholamine levels for the parties replicated throughout the winter period. These replications underscore the strength of such discrete events' influence on the chronic strain of the weather during the austral winter.

Outcome profiles for each environmental factor varied as well. Participants generally habituated to the static environmental demands of the Antarctic setting, but significant changes in physiological and psychological outcomes occurred when other elements in the setting changed. For example, catecholamine and systolic blood pressure levels were negatively associated with increases in wind speed. Self-reports of depression were positively associated with increases in wind speed. In contrast, both systolic and diastolic blood pressure levels were significantly elevated during the end of the winter when the crew exchange was made. Yet there were no significant changes in catecholamines, cortisol, or the mood states of the study participants during the week both the old winter crew and the new summer crew were present. Still another pattern of outcomes was manifested during festivities. Epinephrine and norepinephrine were the only outcome measures that changed due to the festivities.

The unique pattern of outcomes observed associated with each chronic and acute environmental factor could have been due to differences in the demands imposed by each of the independent variables. We can not say that demands simply increased or decreased in this setting. Rather the nature of the demand was determined by both the qualities of that demand and the meaning it had for the individual. One qualitative aspect of demands that may be important in understanding my findings is predictability.

Previous research in other settings has demonstrated that unpredictable environmental demands can be stressful (Cohen, et al., 1986; Glass & Singer, 1972; Seligman, 1973). The energy required to successfully cope with components of the environment can be reduced if those environmental factors are predictable. An individual knows the causal relations between behaviors and outcomes in a predictable environment. If the environment is unpredictable the individual can not anticipate what events will take place. More energy is required to monitor an unknown, unpredictable setting. For example, not being able to predict whether one will be confined indoors because of high winds makes it difficult in an Antarctic research station to establish a consistent outdoor research work schedule. It may have been the unpredictable nature of the wind and resulting physical confinement that caused the study participants to be susceptible to the wind's influence over the course of the winter. In contrast, the more predictable qualities of the ambient setting may have made it an environmental demand that individuals could more readily habituate to.

The end of the winter when the transitions between crews was made appeared to be a stressful time. Answers to questions about stressful aspects of the winter indicated that this was a difficult time for many members of the study. This transitional period was an event who's timing and nature was known. The week in which both the old winter crew and new summer crew were both at the station entailed great changes in the setting. The level of stimuli present greatly increased because of the large influx of people and concommitant changes in use of personal, work, and social areas of the station. The sensitive nature of this time period was reflected in the steps taken by the incoming station management to ease the process. The summer crew was instructed to "take it easy" with the winter crew. Efforts were also made to minimize the time that the winter crew would remain at the station to train the new crew before leaving for the United States. While it was a predictable event, the transition period may have been stressful because there were large and abrupt changes in the level of environmental stimuli present in the setting. The transition also may have been stressful because several of those changes entailed invasive actions such as sharing a previously private territory.

The festivities at the station were very different in character from the other environmental factors measured in the study. The parties were physically arousing, but the arousal was created by positive environmental demands. The pleasant quality of these parties may have accounted for the increase in catecholamines but not in cortisol. Answers on the end of the year questionnaire indicated that in retrospect the fun of planning and participating in these events were among the best aspects of the Antarctic experience. The happy nature of these parties however did not generalize to self-reports of positive mood states taken at the time of the festivities.

Responses to the different acute and chronic factors may also have differed because of physiological and psychological outcomes not measured in this study. For example, increases in blood pressure were observed for the crew transition period at the end of the winter but no significant increase in catecholamines or significant changes in mood were observed. This is in contrast to fluctuations in catecholamines, systolic blood pressure, and depression as wind speed changed during the winter. One of the physiological systems not measured in this study was the parasympathetic nervous system (PNS). The PNS counteracts the actions of the sympathetic nervous system (SNS). The greater the activity level of the PNS, the slower the heart rate and cardiac output of blood. It is possible that the tonic level of the PNS played a role in the level of blood pressure observed. While the catecholamines are linked to increases in blood pressure, it is possible for blood pressure to become elevated without the influence of catecholamines and the increased activation of the SNS. If the SNS activation level remains constant, but the PNS is depressed, blood pressure levels could increase. This might have taken place at the end of the winter during the crew transition when the systolic and diastolic blood pressure levels were elevated but the catecholamine levels were not. In contrast, during periods of good weather when the study participants were not confined to the buildings, systolic blood pressure increases could have been due to the observed increases in the catecholamines alone or in addition to a suppression of the PNS. A future study could consider the influence of the PNS on physiological arousal.

Only three dimensions of mood were measured in this study (anxiety, hostility, and depression). Other mood states such as "level of confusion", "degree of energy", or "spaciness", that were not indexed may have been influenced by the chronic conditions and acute events taking place at the Antarctic site. Some individuals who have spent the winter in Antarctica report feeling "spacy" and find themselves staring off into the distance at no particular object more often then they do in their native country (Taylor, 1969). This mood dimension was not measured in this study. Differences in appraisal and coping strategies might have also provided insights about how and why individuals responded as they did to the acute and chronic factors in the environment.

Mason (1975) and others (Frankenhaeuser, 1975; Lacey, 1967; Obrist, 1981) have argued that stress responses will be specific to the nature of the environmental demand made by a stressor. The differences between outcome measures observed for the various physical and social environmental factors monitored in this research provide support for the specificity of stress responses.

Components of the Dynamics Model of Chronic Stress

I have argued that the chronic stress process is a dynamic environment-person transaction that changes over time as a function of the acute and chronic factors in a setting. In addition, I have stressed that the nature of the environmental stimulus determines the quality of the demand the stimulus makes on the individual. According to this perspective on the chronic stress process, stress measured at any one point in time is due to the the additive impact of the environmental demands of the acute and chronic forces present. In order to capture the dynamic quality of the chronic stress process it is important to monitor different physical and social environmental demands present in a setting and measure their changing influence on stress over time. If stressful settings are treated only as having unchanging environmental demands on the organism an important dimension of the stress process is missed.

In this section of the chapter I discuss components of the dynamic chronic stress process that may be important in predicting stress outcomes. I then turn to methodological and statistical analysis considerations in light of this dynamic construct of chronic stress. I next outline the limitations of the research. Finally I suggest some directions future research might take to further test and develop this construct of chronic stress.

The results of this research indicate that at least four factors are important in considering the dynamic process of chronic stress: the temporal duration of demands; the predictability of demands; the degree of change in environmental demands; and the additive impact of acute and chronic forces in a setting at any one point in time.

<u>Length of exposure.</u> The length of time a physical or social component is present in the setting influences the organism's ability to habituate to the demand. There are two facets to the habituation process: having a sufficient time so that behaviors leading to positive outcomes can be observed; and having a long enough time period so that a shift in reference to what is considered a normative level of environmental stimulation can take place. In order to habituate and successfully adapt to an environmental demand an organism must be exposed to the stimulus long enough to learn what behaviors will lead to positive outcomes in that stimulus' presence. This assumes that a stimulus is predictable (the predictable nature of stimuli will be discussed later). In this study, it is possible that if the winter crew had remained long enough they could have habituated to the presence of the summer crew. The winter crew would have been able to do this because they would have learned those behaviors which would lead to positive outcomes in a setting with larger numbers of people, and because the higher level of environmental stimuli would have become the normative level of stimuli expected in that setting.

The length of time one is exposed to a predictable stressor increases the ability of the organism to shift its frame of reference so that the new level of stimuli present in the setting becomes the perceived normative level of stimulation. It is probable that the winter personnel would have been able to habituate to the increased level of stimulation brought on by the influx of summer crew through a shift in the winter crew's perception of what constitutes a normative level of stimulation. The winter crew had already made a successful transition to the low stimulus setting of the Antarctic winter from the higher level of stimulation present the previous Antarctic summer as evidenced by the relatively stable levels of the outcome measures over the course of the winter.[2]

Predictability. The predictable or unpredictable nature of a stimulus influences the organism's ability to determine the appropriate behaviors to bring about a successful interaction with the environment. If the environmental stimulus is predictable then the organism is better able to make future decisions about which behaviors to utilize to bring about a desired outcome. In this research the study participants were never able to habituate to the unpredictable demands of the weather.

Change in the level of stimulation present in a setting. It is not enough for an environmental stimulus to be predictable in order for a stress response to decrease. Some environmental factors are predictable yet still produce stress because of those factors' negative qualities. The influx of the summer crew at the end of the winter represented a known environmental event that was stressful.

Change in the level of environmental stimuli or change in the nature of the environmental demands made by components of a setting also can cause changes in physiological arousal and psychological mood. The change in environment causes a stress response because the novelty of the new demands require increased monitoring by the organism to make sense of those new demands in the context of previous experience. Novelty is used here to indicate new, unknown qualities of a stimulus. These qualities of novel stimuli make them at least initially unpredictable.

The other facet of change in an environment that elicits a response from the organism is the relative shift in the level of stimuli present when compared with previous levels. If the organism has habituated to the previous level of stimulation in the setting, change in stimuli will not be perceived to be within normative limits and thus will require additional resources to respond. The quality and characteristics of the new stimuli will shape the response of the organism. For example, festivities and the crew transition period represent two different kinds of changes in stimuli that took place in the ICE. The festivities had positive connotations while the transition period was considered a more negative experience. The outcomes represent this difference in meaning even though both events involved an increase in environmental stimulation. The parties at the station were associated with increases in catecholamines while the crew transition was associated with increases in blood pressure.

The additive nature of environmental demands at each point in time. The overlay of chronic conditions and acute events in a setting may place additive demands on individuals. The additive nature of the environmental demands at particular points in time was reflected in the outcomes for those weeks in which both high winds and festivities took place. The positive, arousing influence of parties counteracted the physiologically and psychologically depressing influence of high winds.

Four components of the chronic stress process, the length of exposure to a stimulus, the predictability of the environmental components, change in an environment, and the additive nature of the impact of environmental factors, all played a strategic role in stress outcomes observed in this research. These elements help determine the ability of the individual to habituate to environmental demands, the magnitude of the adaptation response required, and the fluctuations over time in the physiological and psychological responses of the individual.

Methodological Considerations in Researching The Dynamic Properties of Chronic Stress

The results of this research highlight the importance of measuring different acute events and chronic conditions of a setting rather than only measuring the singular impact of the whole setting. In addition, the findings of the study highlight the important role time series research designs and statistical techniques can play in examining the causal sequencing of environmental influences on stress outcomes. The discussion now turns to a consideration of methodological and statistical approaches that permit the investigator to capture the dynamic character of the chronic stress process.

The use of a quasi-experimental time series research design and

ARIMA time series statistical techniques in a field study of chronic stress processes permits the dynamic modeling of those processes. By using these techniques the investigator can look at the causal sequence of environmental input and subsequent outcomes. Using time series designs and statistical approaches, one can examine change in both independent and dependent variables over time. In this manner one can observe whether the fluctuation or changes in the environment are associated with subsequent changes in the study participants' outcome measures. These fluctuations and changes in the environment are natural and not experimentally manipulated. One can observe naturally occurring processes and transactions between the environment and people through the dynamic modeling procedures of ARIMA time series analysis techniques.

This time series approach is in contrast to cross sectional studies which expose one group of individuals to one level of an environmental demand and another group to another level of environmental demand and then make inferences about the stress process. These cross sectional studies do not provide information about the interdependent roles of time and fluctuations in the level of environmental demands in the stress process. In this study it could be observed that as the wind speed changed so did the stress outcome measures. The change in responses over time to changing environmental demands is the dynamic component of the stress process and is excluded when cross sectional studies are used to examine the stress process. Many researchers define stress as a process taking place between people and the environment (Lazarus, 1966; Baum, Singer & Baum, 1982; Cohen, et al., 1986). The term "process" implies a time dependent series of events. Studies which do not collect data over time, and which do not consider each of those time-ordered data points as an important piece of the stress process are unable to measure the dynamic properties of stress. Important time-ordered information is lost when data points are collected over time and then aggregated as a mean value, as is often done in cross sectional stress research.

It is also possible to examine the naturalistic, additive interplay among acute and chronic environmental conditions when time series designs and analytical techniques are used in nonlaboratory settings. In this study it was possible to observe the independent and collective influence of the environmental demands present in the setting over time. It was also possible to see the impact of acute events such as the festivities in the context of other naturally occurring environmental forces. The research design and analyses used in this study made it possible to observe that change in the environment is a major influence on stress outcomes. Change in the environmental characteristics of the setting, such as wind, festivities, and the exchange of crews, resulted in change in outcome variables. At the same time it was able to observe that the predictable ambient quality of the setting was not associated with an increase in the stress responses of the study participants. Investigators who design studies which do not measure the different acute and chronic components of environmental demands over time will not know that such a dynamic interplay takes place in the stress process.

It is also worth considering what conclusions would have been drawn from this study if stress outcomes had only been taken at the beginning and end of the stay in Antarctica, or if study participants' measures were taken at the end of the winter and compared with baseline levels. The high levels of blood pressure at the end of the winter during the crew exchange would have been considered an outcome of the accumulative nature of the stress experienced in an ICE. Gunderson (1968) reported just such an outcome in his research on mental health problems among winter personnel in Antarctica. Using psychometric scales measuring mood he found that Navy winter personnel were more depressed at the end of the winter when compared with self-report measures taken at the beginning of the winter. The data sampling technique in this dissertation research provides support for the interpretation that the stress levels observed at the end of the winter were due to change in the level of environmental demands during the crew exchange rather than the accumulative stress of wintering over. In addition, by using time series design and analytical techniques it was possible to discover how positive acute events compensated for other stressors in the environment.

When longitudinal studies are conducted on chronic stress processes utilizing frequent outcome measures, time series analytical techniques can be used to remove correlations between time-ordered observations due to error. Because this form of error is systematic in nature it tends to inflate t and F statistic values. The use of statistics which do not remove this systematic error can often result in the misrepresentation of data.

Limitations of the Research

Methodological Limitations

The threats to research using time series analyses were discussed in chapter 5 but will be reviewed here briefly. There could have been other environmental forces driving the changes in the outcome variables observed. In order to reduce these kinds of threats to the validity of the study I took the following steps: I developed my hypotheses prior to analyzing the data; I included all known environmental factors in my time series model; and I removed the systematic error in the data through ARIMA modeling procedures. I was not able to address the problem of inaccessable and irregular variables that may have influenced the outcome variables. Irregular and inaccessible variables are best treated by using comparison groups. The role that these kinds of third variables had on the research results will need to be determined in future replication studies.

The time series in this study were relatively short (28 time points). McCain and McCleary (1979) recommend that ARIMA techniques are best used with time series of 50 to 100 time points. Large sample size (data points) are needed not to increase statistical power but to account for the processes in the series (Nurius, 1983). The fashion in which the outcome variables in this study were measured could have been improved. Blood pressure was measured at one point during the day. A better measure of cardiovascular arousal would have been to use ambulatory blood pressure measures to gather data that would have been comparable to the 8-hour urinary measures.

It is also possible that storing the urine samples in ice chest during the 8 hour sampling period may have led to an excessive breakdown of the catecholamines and cortisol. However, assays were conducted to check whether the length of time urine samples were kept on ice influenced the rate of degradation of these endocrine measures. No significant differences were found in levels of catecholamines and in levels of cortisol as a function of time the samples were stored on ice.

The self-report measures of anxiety, depression, and hostility may have been influenced by the study participants' desire to portray themselves as "rugged" Antarctic winter-over personnel. There is evidence to support this concern. The means and the standard deviation of the self-reports of anxiety, hostility, and depression all fell within one standard deviation of normative scores for the POMS bipolar subscales. In addition, the moods that were described in conversations by the study participants with the investigator were often more extreme than those recorded on the POMS forms.

Theoretical Limitations

The dynamics model of chronic stress is an amorphous theory that could be strengthened by clearer definitions of its boundaries. Popper (1972) suggested that the ability to prove a theory false was the criterion of the empirical strength of that theory. If there are principles that direct chronic and acute stress processes then a good theory should aspire to empirically uncover those universal principles. An example of where the dynamics model of chronic stress is amorphous is in the distinction between an organism's capacity to adapt to chronic stressors that are predictable in nature versus those chronic stressors that are not predictable. The boundaries between predictable and unpredictable stimuli is fuzzy. In this study the weather was considered unpredictable, and yet one could predict with some confidence what the weather would be during the following 12 hour period. This lack of clarity in theoretical definitions could permit one to always find support for one's theory. Future research utilizing the dynamics model of chronic stress should move toward more empirical, quantitative definitions in structuring hypotheses.

Another theoretical limitation of this research was the absence of clear delineations between acute and chronic stress, or between acute and chronic stressors. I did not make those delineations because I suspect that acute and chronic stress are two ends of a continuum, as are acute and chronic stressors. However, if one is to draw distinctions between acute and chronic stressors on the basis of an organism's ability to adapt, then there must be guidelines to distinguish between both acute and chronic stressors, and acute and chronic stress.

Suggested Future Research Directions

Future research on chronic stress should examine the dynamic qualities of the process. The environmental demands resulting from the interplay of acute and chronic forces in any setting are constantly in flux. The change in environmental demands on the organism result in fluctuations in the pattern of physiological and psychological outcomes that will be observed. This study has demonstrated the strength of four factors in that chronic stress process: length of exposure to stimuli, predictability of the stimuli, change in environmental demands, and the additive nature of the acute and chronic demands on the individual at each point in time. More information is needed about other characteristics of the chronic stress process that shape the ongoing relationship between the environment and the person. Such characteristics might include the relative magnitude of a demand at any one point in time. It is possible that extreme environments, such as the Nazi concentration camps, do place such a toll on an individual's resources and that a cumulative cost of adaptation would be observed over time.

It is also possible that an individual's ability to foresee an end to a chronic stressor permits him/her to persist in their efforts to meet the demands of the stressor because they know the demand will cease. This is akin to a stressor being controllable because it is predictable. If one knows the demand will end it is a predictable stressor. In this sense the Antarctic winter experience was controllable. It was very important to the winter crew to know when events dictated by officials outside Antarctica were going to take place. For example when the old summer crew took longer than originally scheduled to leave the station before the winter began, this delay appeared to cause some anxiety among both the summer and winter crews. Likewise, as events changed the possible day the new summer crew would arrive at the end of the winter, the winter crew again verbalized their distress. It would be useful to utilize time series techniques to look at the dynamic chronic stress process in a setting that has chronic environmental demands with no known end point. This would help determine whether chronic stressor conditions which have no foreseeable end have different costs.

Behaviors used to adjust to acute and chronic elements of the setting were measured in this research but are not part of the dissertation. It is possible that individuals may change their environment in compensation for environmental deficits. Wohlwill (1974) proposed that behavioral adjustments, such as putting on a jacket in cold weather, are often used by individuals to bring the level of environmental demand into a range that is more comfortable. In the Antarctic setting people may have increased the variety of their behaviors to compensate for the relatively low level of background stimuli present in the isolated setting. Taylor (1969) reports that many the New Zealanders wintering at Scott Base compensated for the low stimulation level of the Antarctic station by devoting much of their leisure time to various activities which were considered stimulating.

The logistical limitations of this research setting also made it difficult to closely examine the outcomes of major shifts in the level of stimuli present as the study participants made the transition from the United States to the Antarctic and then back to the United States again. The study began just after the onset of winter, but several months after any of the winter crew came to the station. It was also not possible to track the participants as they made their reentry into the high stimulus environment of the United States. Research which could examine the adaptation processes people go through in making the transitions to a setting that is very different in the level of stimuli present from the environmental setting they were in previously could be a rich source of information on how people adapt to chronic stressors. Oliver's (1979) interviews with former winter residents of Antarctica indicate that the adaptation back to the high stimulus environment of the United States may be more difficult than the adaptation to Antarctica.

In a different vein, the use of Antarctica as a study site offers valuable information which may broaden our theoretical understanding of more fundamental, human processes. Previous longitudinal studies of stress and arousal processes have been limited by the expense, logistics, and methodological constraints of monitoring subjects over long time periods. Studying these processes in Antarctica allows the use of a nonlaboratory setting in which one is able to control for many extraneous variables present in most other applied field settings. Future research projects in Antarctica could utilize these unique qualities of the setting to examine theoretical questions that generalize beyond isolated and confined environments to principles of human behavior.

Finally, this research adds support to works by Dubos (1965), Wohlwill (1974), Bettelheim (1960), and others who believe that humans are able to adapt to major environmental challenges. Perhaps more meaningful is the ability of people to experience deprivation and harsh times and then draw from those hard times philosophical insights that they believe make them better individuals for the experience. Bettelheim drew a theory of the human psyche and spirit from his experience in the Nazi concentration camps. Others, such as some of the participants in this research, have much simpler insights. Roughly paraphrased, they believed that the challenge of living in Antarctica in close quarters with other people was possible if one could be flexible and take things as they came. The study of person-environment stress processes is made all the more interesting because of this human ability to adapt to unusual and demanding environments and to learn coping skills that can be generalized to other challenging settings.

Reference Notes

1. In a review of the literature on physical mechanisms of stress Henry and Stephens (1977) concluded that depression is associated with heightened arousal of the HPAC axis. This increased activation of the HPAC axis includes elevated secretions of cortisol. In the current research the heightened reports of depression were not associated with increases in cortisol, but were associated with decreases in catecholamines and systolic blood pressure. It is interesting to note that in response to the level of physical confinement present in the setting, self-reports of depression and its bipolar anchor, elation, were linked with outcome measures associated with the suppression or activation of the SAM axis and cardiovascular system but not with the arousal of the HPAC axis. The bipolar scale measures the continuum of mood between elation and depression, not just depression. The activation level of the SAM axis and cardiovascular system was as much a reflection of elation as it was depression.

It is also possible that the levels of depression experienced during periods of high wind were not extreme and as a result did not induce heightened secretions of cortisol. The scores of the study participants support this. The means and standard deviations for the participants on the self-reports of depression all fell within one standard deviation of the normative scores for the POMS bipolar depression scale.

2. The cumulative costs of coping model would also indicate that the length of exposure to a stressor would be associated with aftereffects. According to this theory if the magnitude of a stressor was greater because of the increased length of time an individual was exposed to the stressor, one might expect that the aftereffects would reflect this increase in use of internal resources. The longer the exposure to the stressor, the greater its magnitude of impact, and the larger the aftereffects. Using time series statistical techniques, this impact of stressors through aftereffects would be detected by the length of time lag between the stressor and stress response that proved most significant. In this study all the significant relationships between the independent dependent variables were synchronous. This suggests there were no aftereffects due to the stressors present in the setting. However, the fact that these measures were aggregated by week may have prevented the discovery of such a time lag relationship between stimuli in the environment and responses by the study participants.

Bibliography

Abramson, L., Garber, J. & Seligman, M.E.P. (1980). Learned helplessness in humans: An attributional analysis. In J. Garber & M.E.P. Seligman (Eds.), Human helplessness. New York: Academic Press.

Acheson, K.T., Campbell, I.T., Edholm, O.G., Miller, D.S., & Stock, M.J. (1980). Measurement of daily energy expenditure--an evaluation of some techniques. American Journal of Clinical Nuitrtion, 33,(5), pp. 1155-1164.

Ader, R. (Ed.) (1981). Psychoneuroimmunology. New York: Academic Press.

Altman, I. (1973). An ecological approach to the functioning of isolated and confined groups. In J.E. Rassmussen (Ed.), Man in isolation and confinement. Chicago: Aldine. pp. 241-270.

Altman, I. (1975). The environment and social behavior: Privacy, personal space, territory, and crowding. Monterey, Ca.: Brooks/Cole.

Altman, I. & Haythorn, W. (1967). The ecology of isolated groups. Behavioral Science, 12, pp. 169-182.

Altman, I. & Rogoff, B. (1987). World views in psychology and environmental psychology: Trait, interactional, organismic, and transactional perspectives. In D. Stokols & I. Altman (Eds.), Handbook of environmental psychology. New York: John Wiley & Son.

Ashina, K. (1973) Japanese Antarctic expedition of 1911-12. In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books Ltd. pp. 8-14.

Barabasz, A. & Barabasz, M. (1985) Effects of restricted environmental stimulation: Skin conductance, EEG alpha, and temperature response. Environment and Behavior, 17,(2), pp. 239-253.

Baum, A. & Davidson, L.M. Acute and chronic stress: Psychological differences and research needs. Unpublished manuscript.

Baum, A., Fleming, R.F., & Singer, J.E. (1983). Stress at Three Mile Island: Applying psychological impact analysis. In L. Bickman (Ed.), Applied social psychological annual, (Vol. 3). Los Angeles: Sage.

Baum, A.S., et al., (1985). Urinary catecholamines in behavioral research on stress. In C.R. Lake & M.G. Ziegler (Eds.), The catecholamines in psychiatric and neurologic disorders. London: Butterworths.

Baum, A. & O'Keefe, M. Conceptual and methodological issues in acute and chronic stress. Unpublished manuscript.

Baum, A., Singer, J.E., & Baum, S. (1982). Stress and the environment. In G.W. Evans (Ed.), Environmental stress. New York: Cambridge University Press. pp. 15-44.

Bell, P. & Greene, T. (1982). Thermal stress: Physiological comfort, performance,and social effects of hot and cold environments. In G. W. Evans (Ed.), Environmental Stress. New York: Cambridge University Press. pp. 75-104.

Bernard, C. (1966). Lecons sur les phenomenes de la vie communs aux animaux et aux vegataux. Nouvelle edition. Paris: J. Vrins. (Reprint of volume 1 of 1886 edition).

Bettelheim, B. (1960). The informed heart: Autonomy in a mass age. Genco, IL: Free Press.

Box, G.E. & Cox, D.R. (1964). An analysis of transformations. Journal of the Royal Statistical Society, Series B, 26, pp. 211-243.

Box, G.E., & Jenkins, G.M. (1976). Time series analysis: Forcasting and control. Oakland: Holden-Day.

Broadbent, D.E. (1971). Decision and stress. New York: Academic Press.

Brown, F.M. & Graeber, R.C. (1982). Rhythmic aspects of behavior. Hillsdale, N.J.: Lawrence Erlbaum Associates, Publishers.

Budd, G.M. (1974). Physiological research at Australian stations in the Antarctic and Subantarctic. In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books, Ltd. pp. 27-54.

Byrd, R.E. (1938). Alone. New York: Putnam.

Campbell, J. (1983). Ambient stressors. Environment and Behavior, 15, pp. 355-380.

Cannon, W.B. (1932). The wisdom of the body. New York: Norton.

Carrere, S. Evans, G.W., Palsane, M.N., & Rivas, M. Job strain and occupational stress among urban public transit operators. Unpublished manuscript.

Catalano, R. (1981). Contending with rival hypotheses in correlation of aggregate time-series (CATS): An overview for community psychologists. American Journal of Community Psychology, 9,(6), pp. 667-679.

Catalano, R.A., Dooley, D., & Jackson, R. (1983). Selecting a time-series strategy. Psychological Bulletin, 94,(3), pp. 506-523.

Catalano, R.A., Dooley, D., & Jackson, R. (1985). Economic antecedents of help seeking: A reformulation of time-series tests. Journal of Health and Social Behavior, 26, pp.141-152.

Catalano, R. & Serxner, S. (1987). Time-series designs of potential interest to epidemiologists. American Journal of Epidemiology, 126, (4), pp.724-731.

Cherry-Garrard, A. (1952). The worst journey in the world. London: Chatto and Windus.

Chesney, M. A.& Rosenman, R.H. (1985). Anger and hostility in cardiovascular and behavioral disorders. Washington D.C.: Hemisphere Publishing Corporation.

Clarkson, T.B., Manuck, S. B., & Kaplan, J.R. (1986). Potential role of cardiovascular reactivity in atherogensis. In K.A. Matthews, S.M. Weiss, T. Detre, T.M. Dembroski, B. Falkner, S.B. Manuck, & R.B. Williams (Eds.), Handbook of stress, reactivity, and cardiovascular disease. New York: Wiley. pp. 35-48.

Cohen, S. (1978) Environmental load and the allocation of attention. In A. Baum, J. Singer & S. Valins, (Eds.), Advances in Environmental Psychology, Vol. 1. Hilldale, N.J.: Erlbaum.

Cohen, S., Evans, G.W., Krantz, D., & Stokols, D. (1980). Physiological, motivational, and cognitive effects of aircraft noise on children. American Psychologist, 35, pp. 231-243.

Cohen, S., Evans, G., Stokols, D., & Krantz, D. (1986). Behavior, health and environmental stress. New York: Plenum Press.

Cohen, S. & Weinstein, N. (1982). Nonauditory effects of noise on behavior and health. In G.W. Evans (Ed.), Environmental stress. New York: Cambridge University Press.

Cook, T.D. & Campbell, D.T. (1979). Quasi-experimentation: Design and analysis issues for field settings. Chicago: Rand McNally.

Cook, T.D., Dintzer, L., & Mark, M.M. (1980). The causal analysis of concomitant time series. Applied Social Psychology Annual, 1. pp. 93-135.

Crocq, L., Rivolier, J., & Cazes, G. (1973). Selection and psychological adjustment of individuals living in small isolated groups in the French Antarctic stations. In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books, Ltd. pp. 362-368.

Defayolle, M., Boutelier, C., Bachelard, C., Rivolier, J., & Taylor, A.J.W. (1985). The stability of psychometric performance during the International Biomedical Expedition to the Antarctic (IBEA) .Journal of Human Stress, 11, pp. 157-160.

Dembroski, T.M. et al., (1985). Components of Type A, hostility, and anger-in: Relationship to angiographic findings. Psychosomatic Medicine, 47, pp. 219-232.

Deryapa, N.R., D'iachkov, V.A., Moshkin, M.P., Posnyi, V.S., & Panin, L.E. (1982). Comparative characteristics of seasonal rhythms of physiological functions under arctic and antarctic conditions. Antarktika; Doklady Komissii, Number 21. pp. 175-188.

Doll, R.E. & Gunderson, E.K.E. (1971). Group size, occupational status, and psychological symptomatology in an extreme environment. Journal of Clinical Psychology, 27,(2), pp. 196-198.

Dubos, R. (1965). Man adapting. New Haven: Yale University Press.

Durrett, L.R. & Ziegler, M.G. (1980). A sensitive radioenzymatic assay for catechol drugs. Journal of Neuroscience Research, 5, pp.587-598.

Earls, J. H. (1969). Human adjustment to an exotic environment: The nuclear submarine. Archives of General Psychiatry, 20, pp. 117-123.

Edholm, O.G. (1974). Pysiological research at British Antarctic survey stations. In E.K.E. Gunderson (Ed.), Human adaptability to Antarctic conditions. Antarctic Research Series, Volume 22. Worcester, Massachusett: Heffernan Press. pp. 5-24.

Edholm, O.G. & Gunderson, E.K.E. (1973). Polar human biology. Great Britan: William Heinemann Medical Books, Ltd.

Epstein, S. & Feinz, W.D. (1965). Steepness of approach and avoidance gradients in humans as a function of experience: Theory and experiment. Journal of Experimental Psychology, 77,(1), pp. 1-12.

Evans, G.W. (Ed.). (1982). Environmental stress. New York: Cambridge University Press.

Evans, G. W. (1986). Environmental stress and cognitive performance. In S. Cohen, G. W. Evans, D. Stokols, and D. Krantz, (Eds.), Behavior, Health, and Environmental Stress. New York: Plenum Press. pp. 185-234.

Evans, G.W., & Cohen, S. (1987) Environmental stress. In D. Stokols & I. Altman (Eds.), Handbook of environmental psychology. New York: Wiley. pp. 571-610.

Evans, G.W. & Jacobs, S.V. (1982). Air pollution and human behavior. In G.W. Evans (Ed.), Environmental stress. New York: Cambridge University Press. pp. 105-132.

Evans, G.W., Jacobs, S.V., & Frager, N.B. (1982). Behavioral responses to air pollution. In A. Baum & J.E. Singer (Eds.), Advances in environmental psychology, Vol. 4. Hilldale, N.J.: Erlbaum.

Evans, G.W., Palsane, M.N. Carrere, S. (1987). Type A behavior and occupational stress: A cross-sectional study of blue-collar workers. Journal of Personality and Social Psychology, 52, 5, pp. 1002-1007.

Fleming, R., Baum, A., Singer, J.E. (1984). Toward and integrative approach to the study of stress. Journal of Personality and Social Psychology, 46, pp. 939-949.

Folkman, S. & Lazarus, R.S. (1980). An analysis of coping in a middle-aged community sample. Journal of Health and Social Behavior, 21, pp. 219-239.

Frager, N.B., Phalen, R. & Kenoyer, J. (1979). Adaptation to ozone in reference to mucociliary clearance. Archives of Environmental Health, 34, pp. 51-57.

Frankenhaeuser, M. (1975). Experimental approaches to the study of catecholamines and emotions. In L. Levi (Ed.), Emotions: Their parameters and measurement. New York: Raven Press.

Frankenhaeuser, M., et al., (1989). Stress on and off the job as related to sex and occupational status in white collar workers. Journal of Occupational Behavior, 10, pp. 321-346.

Frankenhaeurser, M. & Johansson, G. (1986). Stress at work: Psychobiological and psychosocial aspects. International review of applied psychology, Vol. 35. London: Sage.

Gentry, W.D. (Ed.). (1984). Handbook of behavioral medicine. New York: The Guilford Press.

Glass, D.C. & Singer, J.E. (1972). Urban stress: Experiments on noise and social stressors. New York: Academic Press.

Glass, G.V., Willson, V. L., and Gottman, J.M. (1975). Design and analysis of time-series experiments. Boulder, Colorado: Associated University Press.

Gunderson, E.K.E. (1968). Mental health problems in Antarctica. Archives of Environmental Health, 17, pp. 558-564.

Gunderson, E.K.E. (1973a). Individual behavior in confined or isolated groups. In J.E. Rassmussen (Ed.), Man in isolation and confinement. Chicago: Aldine. pp 145-166.

Gunderson, E.K.E. (1973b). Psychological studies in Antarctica: A review. In O.G. Edholm & E.K.E. Gunderson, (Eds.), Polar human biology. London: William Heinemann Medical Books, Ltd.

Gunderson, E.K.E. (1974). Psychological studies in Antarctica. In E.K.E. Gunderson, (Ed.), Human adaptability to Antarctic conditions. Antarctic Research Series, Volume 22. Worcester, Massachusett: Heffernan Press. pp. 115-131.

Guyton, A.G. (1987). Human physiology and mechanisms of disease, Fourth Edition. Philidelphia: W.B. Saunders Company.

Haggard, E.A., As, A., & Borgen, C.M. (1970). Social isolates and urbanites in perceptual isolation. Journal of Abnormal Psychology, 76, pp. 1-9.

Harrison, A.A. & Conners, M.M. (1984). Groups in exotic environments. Advances in Experimental Social Psychology, 18, pp. 49-87.

Haynes, S. et al. (1978). The relationship of psychosocial factors to coronary heart disease in the Framingham study. American Journal of Epidemiology, 107,(5), pp. 384-402.

Haythorn, W. (1973). The miniworld of isolation: laboratory studies. In J. E. Rasmussen, (Ed.), Man in isolation and confinement. Chicago: Aldine. pp. 219-240.

Helson, H. (1948). Adaptation level as a basis for quantitative theory of frames of reference. Psychological Review, 55, pp. 297-313.

Henry, J.P. & Stephens, P.M. (1977). Stress, health and the social environment: A sociobiologic approach to medicine. New York: Springer-Verlag.

Herd, J.A. (1986). Neuroendocrine mechanisms in coronary heart disease. In K.A. Matthews, S.M. Weiss, T. Detre, T.M. Dembroski, B. Falkner, S.B. Manuck, & R.B. Williams, (Eds.), Handbook of stress, reactivity, and cardiovascular disease. New York: Wiley. pp. 49-70.

Hockey, R. (1979). Stress and cognitive components of skilled performance. In V. Hamilton & I. Warburton, (Eds.), Human stress and cognition. New York: John Wiley.

Houston, B.K., Smith, M.A., & Cates, D.S. (1989). Hostility patterns and cardiovascular reactivity to stress. Psychophysiology, 26,(3), pp. 337-342.

Ito, Y. (1959). Report on activities on medical subcommittee and medical team for the Japanese Antarctic research expedition. Antarctic Record, 6, pp. 54-72.

Johnston, R.S. & Dietlein, L. F. (Eds.) (1977). Biomedical results from Skylab. NASA: Washington, D.C.

Jennings, J.R. (1985). Attention and coronary heart diseae. In D.S. Krantz, A. Baum, & J.E. Singer, (Eds.), Handbook of psychology and health: Cardiovascular disorders and behavior, Volume 3. Hillsdale, NJ.: Erlbaum. pp. 85-124.

Julius, S., Weder, A.B. & Hinderliter, A.L. (1986). Does behaviorally induced blood pressure variability lead to hypertension? In K.A. Matthews, S.M. Weiss, T. Detre, T.M. Dembroski, B. Falkner, S.B. Manuck, & R.B. Williams, (Eds.), Handbook of stress, reactivity, and cardiovascular disease. New York: Wiley. pp. 71-84.

Kant, G.J., Eggleston, T., Landman-Roberts, L., Kenion, C.C., Driver, G.C., & Meyeroff, J.C. (1985). Habituation to repeated stress is stressor specific. Pharmacology, Biochemistry and Behavior, 22, pp. 631-634.

Karasek, R. (1979). Job demands, job decision latitude, and mental strain: Implications for job redesign. Administrative Science Quarterly, 24, pp. 285-306.

Karasek, R., _et al._, (1981). Job decision latitude, job demands, and cardiovascular disease: A prospective study of Swedish men. _American Journal of Public Health_, _71_, pp. 694-705.

Karasek, R. A., Russell, S., & Theorell, T. (1982). Physiology of stress and regeneration in job related cardiovascular illness. _Journal of Human Stress_, March, pp. 29-42.

Kasl, S. (1984). Stress and health. _Annual Review of Public Health_, _5_, pp. 319-341.

Kinsey, J.L. (1959). Psychological aspects of Nautilus transpolar cruise. _United States Armed Services Medical Journal_, _10_,(4), pp.451-462.

Kirtz, S. & Moos, R.H. (1974). Physiological effects of social environments. _Psychosomatic Medicine_, _36_,(2), pp. 96-114.

Krantz, D. & Manuck, S. (1984). Psychophysiologic reactivity and risk of cardiovascular disease: A review and methodological critique. _Psychological Bulletin_, _96_,(3), pp. 435-464

Lacey, J.I. (1967). Somatic response patterning and stress: Some revisions of activation theory. In M.H. Appley & R. Trumbell (Eds.), _Psychological stress: Issures in research_. New York: Appleton- Century-Crofts.

Laing, E.W. & McFarlane, W. (1972). _Solving problems in dynamics, electricity and magnatism_. Edinburgh: Oliver and Boyd.

Law, P. (1960). Personality problems in Antarctica. _Medical Journal of Australia_, _47_, pp. 273-282.

Lazarus, R.S. (1966). _Psychological stress and the coping process_. New York: McGraw-Hill.

Lazarus, R.S. & Cohen, J. (1977). Environmental stress. In I. Altman & J. Wohlwill (Eds.), _Human behavior and environment_, _Vol. 2_. New York: Plenum Press.

Lazarus, R.S. & Folkman, S. (1984). _Stress, appraisal, and coping_. New York: Springer Publishing.

Lazarus, R.S. & Launier, R. (1978). Stress-related transactions between person and environment. In L.A. Pervin & M. Lewis (Eds.), _Perspectives in international psychology_. New York: Plenum Press.

Little, B.R., (1983). Personal projects: A rationale and method for investigation. Environment and Behavior, 15,(3), pp. 273-309.

Lobban, M.C. (1973). Circadian rhythms in the Eskimo. In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books Ltd. pp. 306-314.

Lorr, M., & McNair, D.M. (1984). Manual of Profile of Mood States. San Diego: Educational and Industrial Testing Service.

Lundberg, U. (1980). Catecholamines and cortisol excretions under psychologically different laboratory conditions. In E. Usdin, R. Kvetnansky, & I.J. Kopin (Eds.), Catecholamines and stress: Recent advances, Proceedings of the Second International Symposium on Catecholamines and Stress. Snolenice Castle, Czechoslovokia. September 12-16, 1979. New York: Elsevier North-Holland.

Lundberg, U. & Frankenhaeuser, M. (1980). Pituatary-adrenal and sympathetic-adrenal correlates of distress and effort. Journal of Psychosomatic Research, 24, pp. 125-130.

Manuck, S. & Krantz D. (1986). Psychophysiological reactivity in coronary heart disease and essential hypertension. In K.A. Matthews, , S.M. Weiss, T. Detre, T.M. Dembroski, B. Falkner, S.B. Manuck, & R.B. Williams (Eds.), Handbook of stress, reactivity, and cardiovascular disease. New York: Wiley. pp. 11-34.

Mason, J.W. (1975). Emotions as reflected in patterns of endocrine integration. In L. Levi (Ed.), Emotions: Their parameters and measurement. New York: Raven Press.

Mason, J.W., Mahr, J.T., Hartley, L.H., Mougey, E.H., Perlow, M.J., & Jones, L.G. (1976). Selectivity of corticosteroid and catecholamine responses to various natural stimuli. In G. Serban (Ed.), Psychopathology of human adaptation. New York: Plenum Press.

Matthews, K.A. (1986). Summary, conclusions, and implications. In K.A. Matthews, , S.M. Weiss, T. Detre, T.M. Dembroski, B. Falkner, S.B. Manuck, & R.B. Williams (Eds.), Handbook of stress, reactivity, and cardiovascular disease. New York: Wiley. pp. 461-474 .

Matthews, K.A., Weiss, S.M., Detre, T., Dembroski, T.M., Falkner, B., Manuck, S.B., & Williams, R.B. (Eds.), (1986). Handbook of stress, reactivity, and cardiovascular disease. New York: Wiley.

McCain, L.J. & McCleary, R., (1979). The statistical analysis of the simple interrupted time-series quasi-experiment. In T.D. Cook and D.T. Campbell (Eds.), Quasi-experimentation: Design and analysis issues for field settings. Boston: Houghton Mifflin Company. pp. 233-294.

McCleary, R., Hay, R.A. Jr., Meidinger, E.E., & McDowall, D. (1980). Applied time series analysis for the social sciences. Beverly Hills: Sage Publications.

McCormick, I.A., Taylor, A.J.W., Rivolier, J., & Cazes, G. (1985). A psychometric study of stress and coping during the International Biomedical Expedition to Antarctica (IBEA). Journal of Human Stress, 11, pp.150-156.

McCubbin, J.A., et al., (1983). Sympathetic neuronal function and left ventrical performance during behavioral stress in humans: The relationship between plasma catecholamines and systolic time intervals. Psychophysiology, 20, (1), pp. 102-110.

McGuire, F., & Tolchin, S. (1961). Group adjustment at the South Pole. Journal of Mental Science, 107, pp. 954-960.

McNeal,S. R. and Bluth, B. J. (1981). Influential factors of negative effects in the isolated and confined environment. The Fifth Princton AIAA/SSI Conference on Space Manufacturing.

Mechanic, D. (1962). Students under stress: A study in the social pschology of adaptation. New York: The Free Press of Glenco.

Meschievitz, C.K., Raynor, W.J., Dick, E.C., & Mandel, A.D. (1983). Cold severity, duration and epidemiology in persons emerging from isolation compared to newly arrived persons at McMurdo Station. Antarctic Journal of the United States, 18,(5), pp. 232-234.

Milgram, S. (1970). The experience of living in cities. Science, 167, pp. 1461-1468.

Muchmore, H.G., Parkinson, A.J., & Scott, E.N. (1983). Respiratory virus infections during the winter at the Sout Pole. Antarctic Journal of the United States, 18,(5), pp. 229-230.

Nardini, J.E., Hermann, R.S. & Rasmussen, J.E. (1962). Navy psychiatric assessment program in Antarctica. American Journal of Psychiatry, 119, pp. 97-105.

Natani, K. & Shurley, J.T. (1974). Sociopsychological aspects of a winter vigil at South Pole Station. In E.K.E. Gunderson, (Ed.), Human adaptability to Antarctic conditions. Antarctic Research Series, Volume 22. Worcester, Massachusett: Heffernan Press. pp. 89-114.

Nelson, P.D. (1973). The indirect observation of groups under confinement and/or isolation. In J.E. Rasmussen (Ed.) Man in isolation and confinement. Chicago: Aldine. pp. 167-194.

Nurius, P.S. (1983). Use of time-series analysis in the evaluation of change due to intervention. Journal of Applied Behavioral Science, 19,(2), pp. 215-228.

Obrist, P. A. (1981). Cardiovascular psychophysiology. New York: Plenum Press.

Obrist, P.A., et al., (1978). The relationship among heart rate carotid dp/dt and blood pressure in humans as a function of the type of stress. Psychophysiology, 15, pp. 102-115.

Oeda, G., (1978). On cold adaptation. Anthropological Society of Nippon, 86,(1), pp. 19-21.

Ogata, M. (1959). Report on physiological results of the Japanese Antarctic research expedition. Antarctic Record, 6, pp. 47-53.

Oliver, D.M. (1979). Some psychological effects of isolation and confinement in an Antarctic winter-over group. Dissertation. United States International University, San Diego.

Ostrom, C.W. Jr. (1983). Time series analysis: Regression techniques, Beverly Hills: Sage Publications.

Palmai, G. (1963). Psychological observations on an isolated group in Antarctica. British Journal of Psychiatry, 109, pp. 364-370.

Pitman, D.L., Ottenweller, J.E., Natelson, B.H. (1988). Plasma corticosterone levels during repeated presentation of two intensities of restraint stress: Chronic stress and habituation. Physiology & Behavior, 43, pp. 47-55.

Popper, K.R. (1972). Objective knowledge: An evolutionary approach. Oxford, England: Clarendon Press.

Poulton, E.E. (1977). Continuos intense noise masks auditory feedback and inner speech. Psychological Bulletin, 84,(5), pp. 979-1001.

Radloff, R., Helmreich, R. (1968). Groups under stress: Psychological research in SEALAB II. New York: Appleton-Century-Crofts.

Rasmussen, J.E. (Ed.) (1973). Man in isolation and confinement. Chicago: Aldine.

Rivolier, J. (1973). Review of medical research performed in the French Antarctic territories. In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books, Ltd. pp. 48-53.

Rivolier, J. (1974). Physiological and psychological studies by continental European and Japanese expeditions. In E.K.E. Gunderson, (Ed.), Human adaptability to Antarctic conditions. Antarctic Research Series, Volume 22. Worcester, Massachusett: Heffernan Press. pp. 55-70.

Rosenman, R.H., et al., (1975). Coronary heart disease in the Western Collaborative Group Study: Final follow-up experience of 8 1/2 years. Journal of the American Medical Association, 233, pp. 872-877.

Scheiderman, N. (1985). Animal behavior models of coronary heart disease. In D.S. Krantz, A. Baum, J.E. Singer (Eds.), Handbook of psychology and health: Cardiovascular disorders and behavior, Volume 3. Hillsdale, NJ.: Erlbaum. pp. 19-56.

Seligman, M.E.P. (1975). Helplessness: On depression, development, and death. San Francisco: Freeman.

Sells, S.B. (1973). The taxonomy of man in enclosed space. In J.E. Rasmussen (Ed.), Man in isolation and confinement. Chicago: Aldine. pp. 281-304.

Selye, H. (1956). The stress of life. New York, N.Y.: McGraw-Hill.

Shurley, J.T. (Ed.) (1970). Man on the South Polar Plateau. Archives of Internal Medicine, 125, pp. 625-659.

Shurley, J.T. (1974). Physiological research at United States in Antarctica In E.K.E. Gunderson (Ed.), Human adaptability to Antarctic conditions. Antarctic Research Series, Volume 22. Worcester, Massachusett: Heffernan Press. pp. 71-88.

Simpson, H.W., Bellamy, N., Bohlen, J., & Halberg, F. (1973). Polar summer—A natural laboratory for human circadian rhythm studies of a simulated time-zone shift and test of a potential chronobiotic (Quiadon). In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books Ltd. pp. 297-305.

Siple, P.A. (1959). 90° South: The story of the American South Pole conquest. New York: Putnam Press.

Sklar, L.A. & Anisman, H. (1981). Stress and cancer. Psychological Bulletin, 89,(3), pp. 369-406.

Smith, W.M. (1966). Observations over the lifetime of a small isolated group: Structure, danger, boredom, and vision. Psychological Reports, 19, pp. 475-514.

Smith, W.M. & Jones, M.B. (1962). Astronauts, antarctic scientists, and personal autonomy. Journal of Aerospace Medicine, 33, pp. 162-166.

Steinberg, L., Catalano, R., & Dooley, D. (1981). Economic antecedents of child abuse and neglect. Child Development, 52, pp. 260-267.

Stokols, D. (1979). A congruence analysis of human stress. In I.G. Sarason & C.D. Spielberger (Eds.), Stress and anxiety, Vol. 6. Washington D.C.: Hemisphere.

Stokols, D. (1987). Conceptual strategies of environmental psychology. In D. Stokols & I. Altman (Eds.), Handbook of environmental psychology. New York: John Wiley & Sons.

Stokols, D. & Altman, I. (Eds.). (1987). Handbook of environmental psychology. New York: John Wiley & Sons.

Stokols, D., Novaco, R.W., Stokols, J., & Campbell, J. (1978). Traffic congestion, Type-A behavior, and stress. Journal of Applied Psychology, 63,(4), pp. 467-480.

Suedfeld, P. (1974). Social isolation: A case for interdisciplinary research. The Canandian Psychologist, 15,(1), pp. 1-15.

Suedfeld, P. (1980) Restricted environmental stimulation. New York: John Wiley & Sons.

Taylor, A.J.W. (1969). Ability, stability, and social adjustment among Scott base personnel, Antarctica. Occupational Psychology, 43, pp. 81-93.

Taylor, A.J.W. (1973). The adaptation of New Zealand research personnel in the Antarctic. In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books, Ltd. pp. 417-429.

Taylor, A.J.W. & McCormick, I.A. (1985). Human experimentation during the Biomedical Expedition to the Antarctic (IBEA). Journal of Human Stress, 11, pp. 161-164

Taylor, D. A., Wheeler, L., & Altman, I. (1968). Stress reactions in socially isolated groups. Journal of Personality and Social Psychology, 9, pp. 369-376.

Timio, M., Gentili, S. & Pede, S. (1979). Free adrenaline and noradrenaline excretion related to occupational stress. British Heart Journal, 42, pp. 471-474.

Topfer, M. (1980). Investigations of the long-term biological rhythms with emphasis on the 7-day variations. Geodatische und Geophysikalische Veroffentlichungen,Ser. 1, No. 9. pp. 166-171.

United States Antarctic Research Program Personnel Manual (1983). Washington D.C.: Department of Polar Programs, National Science Foundation.

Ursin, H., Baade, E., & Levine, S. (1978). Psychobiology of stress: A study of coping men. New York: Academic Press.

Vinsel, A., Brown, B.B., Altman, I., & Foss, C. (1980). Privacy regulation, territorial displays, and effectiveness of individual functioning. Journal of Personality and Social Psychology, 39,(6), pp. 1104-1115.

Watanabe, K. (1967). The physiological acclimatization in the fourth Japanese Antarctic reseach expedition 1959-61. In S.W. Tromp (Ed.) Biometerology, Volume 2,Part2. New York: Pergamon Press. pp. 880-884.

Weiss, J.M., Glazer, H.I., Pohorecky, L.A., Brick, J. & Miller, N.E. (1975). Effects of chronic exposure to stressors on avoidance-escape behavior and on brain norepinephrine. Psychosomatic Medicine, 37, pp.522-534.

West, P. (1985). Medical Physiology. Baltimore: Williams & Wilkins.

Weybrew, B.B. & Noddin, E.M. (1979). Psychiatric aspects of adaptation to long submarive missions. Aviation, Space, and Environmental Medicine, 50, pp. 575-580.

White, R. (1959). Motivation reconsidered: The concept of competence. Psychological Review, 66,(5), pp. 297-333.

Williams, R.B. (1985). Neuroendocrine response patterns and stress: Biobehavioral mechanisms of disease. In R.B. Williams (Ed.), Perspectives on behavioral medicine: euroendocrine control and behavior. New York: Academic Press.

Williams, R.B. et al. (1980) Type A behavior, hostility and coronary atherosclerosis. Psychosomatic Medicine, 42, pp. 539-549.

Wilson, E.A. (1966). Diary of the 'Discovery' expedition. London: Blandford.

Wohlwill, J.F. (1974). Human adaptation to levels of environmental stimulation. Human Ecology, 2,(2), pp. 127-147.

Yoshimura, H. (1973) Review of medical researches (sic) at the Japanese station (Syowa Base) in the Antarctic. In O.G. Edholm & E.K.E. Gunderson (Eds.), Polar human biology. London: William Heinemann Medical Books Ltd. pp. 54-65.

Zubeck, J.P. (1973). Behavioral and Physiological effects of prolonged sensory and perceptual deprivation: A review. In J.E. Rasmussen (Ed.), Man in isolation and confinement. Chicago: Aldine. pp. 9-84.

APPENDIX

Human Subjects Consent Form

Physiological Information and 24 Hour Log

POMS Adjective Checklist

Beginning of Winter Questionnaire

UNIVERSITY OF CALIFORNIA IRVINE
HUMAN ADAPTATION TO AN ISOLATED AND CONFINED ENVIRONMENT
Gary W. Evans, S. Carrere, Dan Stokols
Program in Social Ecology

CONSENT TO ACT AS A HUMAN RESEARCH SUBJECT

Name of Subject ________________________________

Purpose of the Study

This research will provide detailed information about physiological and psychological adaptation to an Antarctic isolated and confined environment during the six and a half month winter season. It will examine the types of activities that are participated in and compare them with physiological and psychological outcomes. This research also looks at how individuals modify such an environment so as to strengthen their attachment to it.

Procedures and Duration

The study will last six and a half months. Participants in the research will be asked to do the following:

3 times a week fill out a mood adjective checklist (5 minutes)
2 times a week have blood pressure taken (5 minutes)
1 time a week give 8 hour urine sample (5 minutes)
1 time a month fill out activity schedule (20 minutes)
3 times during the study fill out questionnaire (40 minutes)
1 time after the study fill out follow up questionnaire (40 minutes)

In addition participants are asked permission to have their rooms photographed periodically and to be included in a census of where people are working in the station once a day.

Risks

Efforts have been made to eliminate any possibility of risk including physical, psychological, social or legal. The major source of risk might come through public identification of the subjects. To eliminate this possibility the following steps will be taken:

1. At no time will the names of the participants ever be written down in association with the code names and numbers used to identify their data.

2. Subject numbers will be given to each of the participants to identify physiological measures; interviews; photographs of personal rooms, and the three questionnaires.

3. Participants will be asked to pick a code name and submit that code name with their subject number to the investigator. These envelopes will not be opened until after the investigator has returned to the United States. The participants will be asked to use their code name to identify activity schedules, and mood adjective check lists. The forms with the code name will be turned into a box rather than directly to the investigator.

4. Participants will put subject numbers on any follow-up forms used after the winter season.

It is also possible that participants in the study will find it an inconvenience to interrupt their daily schedule to complete the procedures in the study.

Benefits
The findings of this study will be used in the design and activity programming of the proposed space station. It's findings may also be useful in understanding the special needs of inhabitants of other isolated and confined environments.

CONFIDENTIALITY will be protected to the extent provided by law. If at any time you have questions regarding the research or your participation, you should contact the investigator or his/her assistants who must answer the questions.

PARTICIPATION IN RESEARCH IS ENTIRELY VOLUNTARY. You may refuse to participate or withdraw from participation at any time without jeopardy to employment, education or other entitlements.

If at any time you have comments or complaints relating to the conduct of this research, you may contact the Human Subjects Committee's Office, 145 Administration Building, UC Irvine, Irvine, CA 92717.

I consent to participate in those aspects of this study I have initialled below.

____
Signature of Subject Date

____
Signature of Parent/Guardian Date

Children age 7 and older must sign the consent form, assenting to participation. Parent or guardian must sign, giving legal consent.

______Measurement of blood pressure.

______Measurement of urinary adrenaline and noradrenaline (8 hr. samples)

______Adjective checklist measuring mood change.

______Activities schedule.

______Inventory of personal items.

______Photographs and videos of bedroom to look at how people personalize their private space.

______Daily census of public areas to determine where people are working or recreating on station.

Physiological Information

Participant number______ Time Blood Pressure taken______
Date_________

The time he got up______

Number of cups of caffinated coffee,tea, or soda?________________

What alchohol, if any, has the person had
today? _____________________

Systolic Blood Pressure_______ Diastolic Bld. Pr.______________

Activities today (approx. amount of time for each)

____
____
____
____
____

Places on station this person was from this time yesterday until bed:

____
____
____
____

Urine Volume____________________ 2 x 5 ml. samples taken____

TOMORROW YOU ARE SCHEDULED TO: ______HAVE YOUR BLOOD PRESSURE TAKEN
______GIVE AN 8 HOUR URINE SAMPLE
______FILL OUT THIS ADJECTIVE FORM

PLEASE FILL OUT THIS ADJECTIVE LIST FORM BETWEEN
______________________ TOMORROW

Code name__________________ Date and time________________________

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195, Mood Checklist

University Microfilms International

Participant number________

This questionnaire contains a series of questions about your background. Answers to all questions are voluntary and will be kept completely confidential. Please do not put your name on any of the pages. Only write your participant number where indicated on this first page. If any question does not make sense, please ask for clarification. I appreciate the time and effort you are giving in helping me with my research.

1. What is your age? ________
2. What is your marital status?
   ( ) single
   ( ) married / living with a partner
   ( ) separated/ divorced
   ( ) widower
3. How many children do you have? ________

4. Please indicate the highest level of education you have received

( ) elementary school

( ) high school

( ) some technical/vocational training

( ) some college, no degree

( ) associate degree

( ) bachelor's degree

( ) master's degree

( ) doctoral degree

( ) post doctoral

5. current weight ____________

6. Do you smoke cigarettes? ( ) yes ( ) no

7. How long have you been in Antarctica on this trip? (date of arrival) ____________________.

8. In the space provided below please record your previous trips to Antarctica. Please list the station you were at and the time period you were there. An example is given.

Station	Length of Stay
example: McMurdo	Jan. 10 - Feb. 15 1983