JOB CHARACTERISTICS, OCCUPATION

AND

CORONARY HEART DISEASE

by

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(Many of these tables will be updated by conference time as we make minor scale modifications based on the inclusion of women, and as we explore new data bases).

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ABSTRACT

In the present study we test both a new model of job-related CHD risk, and introduce a new technique for assessing the effects of job characteristics of detailed occupational groups. The model of job-related CHD risk has been successfully tested in Sweden with incidence data at the individual level. However, because good job data is lacking in major U.S. cardiovascular data bases in order to test for comparable U.S. associations, we are obliged to develop a methodology for linking the data bases concerning job conditions and CHD incidence, respectively (a methodology which also can be applied to occupational diseases other than heart disease). We use major national surveys of job characteristics by U.S. occupation code to compile occupational means on a range of salient job characteristics. These job scores can then be applied to any CHD survey with U.S. Census occupation codes. Analytic tests can then be made on models of job characteristics which could be CHD risk factors. Our information about job characteristics for occupational groups is derived from three national samples of the U.S. Quality of Employment Surveys (1969, 1972 and 1977). In addition, occupational scores are adjusted for the effects of demographic factors such as sex, age, race and education. These scores are applied, in this paper, to two U.S. national surveys of CVD illness prevalence (HES 1960-1961 [still in progress] and the HANES 1971-74) to test hypotheses about the association between specific job characteristics and myocardial infarction. In general, the model of CHD risk, based on low control on the job and high psychological work load, is confirmed. Our inference method also allows previous findings about job characteristics of specific occupations to be reviewed against the background of a comparative national framework, and for occupations simultaneously at risk on several factors to be identified for future, more detailed field studies.

A. REVIEW OF THE JOB SCORING SYSTEM A job characteristic scoring system is developed to predict the health, productivity and social well-being correlates of job activity. The system generates scores for fourteen dimensions of work activity for any individual whose job title and industry are known using the U.S. Department of Labor surveys of the full U.S. work force in 1969, 1972, and 1977: Job Decision Latitude (skill discretion, decision authority), Job Stressors (psychological work load, hours of work, job insecurity), Social Support (supervisor, co-worker), Physical Exertion, and

Physical Hazard Exposure (noise, temperature/humidity, injury/toxic substances). Respondents' reports about their jobs are first averaged for the U.S. Census 1970 occupations, based on the assumption of three independent samples (from the same population). For males, 211 occupations, representing 98% of the work force, can be scored in this manner. A complete analysis of scale variance is performed, including between-occupation variance, unexplained reliable (or systematic) variance, between-survey variance, and scale unreliablity. In general, the scores are found to be high on replicability between surveys, to be moderate in scale reliability and to correlate rather well with comparable dimensions in DOT. The crucial between-occupation reliable variance of the scores is substantial for decision latitude, job insecurity and physical demands, but low for social support and psychological work load. When the job scores are compared to conventional status measures such as Duncan S.E.I., measures of job experience predict the majority of Duncan scale variance, and predict a markedly larger percentage of variance than does the Duncan Scale in psychological strain and heart disease. This is probably because of complex associations masked when unidimensional status measures are used. The distribution of job scores for all occupations on two job dimensions (significantly associated with psychological illness) isolates conceptually distinguishable "patterns" of occupational activity. Comparison of men and women's distribution illustrate major differences in both levels of job scores and differences in inter-score correlations.

B. In the second half of the discussion of our system, methodologies for use of the system are reviewed. First, additional precision and reduced bias in the scores is generated by adjusting them for the individual's age, race, marital status, region and self-employment. Analysis using the adjusted scores is compared to two-stage least squares using occupation as an instrumental variable. Estimates are made of the lost explanatory power due to substitution of occupation-based estimates for true, individual-level job scores. Prediction of a sample illness indicator (life dissatisfaction depression), using both estimates and true individual level scores, reveals that the occupation-based estimates replicate the true associations well (with lost statistical power), and that the demographic adjustments diminish bias as predicted. Discussing another methodological approach, the occupation-level score reliabilities are reviewed as a basis for use of the scoring system at the occupation-level (for identification of occupations at risk for illness, for example). Occupations high in psychological strain are identified and their distribution is discussed.

C. REVIEW OF JOB/CHD FINDINGS Associations between past myocardial infarction (M.I.) prevalence and job characteristics are reported among employed white males in one large scale clinical survey of cardiovascular illness: the US Health and Nutritional Examination

Survey (HANES) 1971 - 1974 (N = 2153). US Census occupation codes (441 categories), industry, and self-employment status are available on the survey. The job characteristics inference method is used which imputes scores to census occupation codes based on national surveys (US Quality of Working Life Surveys: 1969, 1972, and 1977). Job characteristic hypotheses are tested using these occupational scores as simple means and as means adjusted for demographic factors such as age, race, education, self-employment, marital status, urbanicity, and religion. Controlling for age (race, sex) and using mean job scores, we find that jobs which are simultaneously low in decision latitude and high in psychological work load (a multiplicative interaction isolating 25% of the population) have significantly higher prevalence of myocardial infarction ($p \leq 0.001$ HANES), confirming findings in Swedish incidence data using a similar job characteristic model and cardiovascular mortality. In a further multiple logistic regression analysis using the scores adjusted for demographic factors and controlling for age, education, systolic blood pressure and smoking, we find low decision latitiude to be significantly associated with myocardial infarction prevalence in the HANES ($p \leq 0.003$). Psychological job demands are positively associated with M.I. in the HANES, ($p \leq 0.02$). Job Physical exertion is negatively associated with M.I. prevalence in the HANES ($p \leq 0.002$).

ACKNOWLEDGEMENTS:

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I. REVIEW OF EPIDEMIOLOGICAL LITERATURE AND DEFINITION OF THE PROBLEM

The first simple test for any relationship between job experience and coronary heart disease (CHD) would be a demonstration that broadly aggregated measures of occupation, such as socio-economic status, show a clear relationship to CHD. Unfortunately, the conventional understanding has been that CHD is, at best, ambigiously related to social class (Epstein, 1967; Antonovsky, 1968). During the last two decades however, findings of a negative relationship between occupational social status and CHD incidence have begun to present a consistent picture, (Sundbom, 1978; Hinkle et al, 1968; Pell and D'Alonzo, 1963; Leren, 1980; and Marmot, 1978).

An understanding of the implications for associations between job situations and CHD is hindered by the global manner in which the status measures (income, education, social class, SES scores) summarize occupational experience. Attempts to arrive at a more specific understanding of the occupational status associations have led to contradictions: physical demands are higher in low status jobs and yet physical exertion has generally been found to be protective with respect to CHD (Milvy et al, 1977; Paffenbarger and Hale, 1975). Psychological work load, deadlines and overtime work, which have generally been associated with increased risk of CHD (see p. 6 below), are somewhat lower in low status jobs (Karasek, 1981a). Finally, serum cholesterol, which has been clearly associated with CHD risk in many studies, is lower in lower status groups (Marmot, et al 1978). These contradictions imply that there may be "aggravating factors," based on as yet unknown characteristics of occupation, which increase the lower status prevalence of CHD - in spite of lower risk on known risk factors. If such "aggrevating factors" are obscured in conventional social status measures (as we find in Chapter III) most previous analyses based on such measures could significantly understate the impact of job on CHD. Unfortunately few comphrehensive models or inventories of CHD relevent, job-related risk factors now exist to expedite further investigation.

Compelling evidence exists for the need to examine in greater detail the

association between specific job characteristics and coronary heart disease. House terms the search for specific job characteristics that could explain occupational differences in CHD mortality, "the sine qua non for establishing work-experience as an explanation of occupational differences in heart disease" (House, 1974). Sales and House (1971) found a strong association between job dissatisfaction (which itself is highly related to specific job task characteristics) and CHD, which remained unchanged when controlled for conventional social status measures (the average correlation coefficient dropped from .63 to .61 in four reported groups when status was controlled). A recent re-analysis of the Framingham data (Haynes, et al, 1978a) has shown that the conventional risk factor associations with CHD are much stronger in the white-collar/professional groups (n=170, 8th and 9th year) than in the much larger blue-collar group (n=570, 8th and 9th year). The specificity of occupational influence on CHD etiology is further demonstrated by the finding that for women, work experience per se is not a risk factor for CHD (Haynes, et al, 1978b), but clerical jobs are higher in risk. Reinterpretation of CHD data on large surveys in the United States also sheds light on possible occupational associations with CHD. In studies by Kitagawa and Hauser, there is a dramatic drop in CHD/income-education associations after age 65. This discontinuity at age 65 suggests that it is not income or education per se that is responsible for this variation but something closely related to them which changes at age 65, possibly retirement from the work experience itself.[1]

Other recent evidence for the importance of work activity comes from the

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[1]That is to say, the otherwise "curious" drop in the association between education or income and mortality for individuals over age 65 may be explained, if the variables education and income are considered proxy measures for "risky" job conditions which really lead to increased mortality (and which changes abruptly at age 65). Studies by Kitagawa and Hauser (1973), (340,033 U.S. Census Records), Comstock and Tonascia (1977) (47,423 Maryland residents), and Brenner (1980) show a strong inverse relationship between education and mortality. Circumstantial evidence for an impact of occupation can be gleaned from the four tables from Kitagawa and Hauser.

findings of Dr. Simon Rabkin. In a study on 3983 Canadian males, he found that 48% of all incidents of cardiac sudden death occurred on Mondays, along with 75% of all myocardial infarctions occurring on the job itself (Rabkin and Matthewson, 1980). Of course the most salient characteristic of "Monday" all over the modern world is that it marks the resumption of the job stress burden after a day or more of relaxation. This relatively rapid job-related acceleration of stressors on Mondays may be a major triggering event in CHD.

Review of the studies that have been performed on the association between specific job characteristics and CHD yields a rather incomplete picture. Probably the most often utilized model of job related CHD, since Osler (1892), is based on the potentially deleterious effects of psychological stressors such as work load (Buell and Breslow, 1960; Friedman, Rosenman and Carrol, 1958; Russek and Zohman, 1958). Excessive overtime work (Hinkle et al, 1968) and a combination of physically demanding work and psychological work load (Theorell and Floderus-Myrhed, 1977) have also been identified with CHD risk. The stress related phenomenon of job dissatisfaction (Karasek, 1979a) has also been implicated in CHD (Sales and House, 1971; Blohmke et al, 1969; although not Theorell and Floderus-Myrhed, 1977). There is no evidence or theory, however, to suggest that the above researched list of job characteristics is exhaustive. "Job stress models" have not been extensively developed. In their place a linear approach, where "stressors" are simply added together in undifferentiated manner to predict accumulated risk, is the common analytic strategy (similar to the "stressful life event" research of Holmes and Rahe, (1967); see Dohrenwend and Dohrenwend (1974) for discussion).

One early implication of "stress" as a causal agent for CHD is that it has opened the door to research efforts by psychologists to determine whether "a stressful personality" type must be responsible for observed associations (through job selection). Unfortunately, in our opinion at least, the dominant emphasis in psychology (and medicine as well)--on problems of the person rather than problems of the environment--seems to have shifted "stress and CHD" attention away from job related causes to concern for "coronary prone personality traits." For example, when Friedman, Rosenman, and Carroll

demonstrated that serum cholesterol rises and blood clotting time falls for tax accountants before the April 15th tax deadline (Friedman, et al, 1958), they clearly showed the significance of psychosocial environmental factors. Rather than more detailed examination of such work environment factors, however, most subsequent research in this tradition has focused on the "Type A personality", as measured by questionaires on personal response style. There is a possibility that attempts to measure personality in the job situation really record (at least in part) differences in the job situation itself: the stressful job instead of the anxiety prone person. Misinterpretation of such measurements could have important implications for health care policy. While both environment and personality risk factors could be valid components of a comprehensive psychosocial model of CHD, they have decidedly different implications for prevention strategy. When the individual's personality is the source of difficulty, behavior modification techniques might be appropriate (Glass, 1977). However, when the work environment is the primary risk factor, it is the job, not the patient which should be modified.

One solution to this dilemma is more sophisticated methodologies for work environment research. One environmentally-oriented approach has been the examination of CHD risk in specific occupational groups. This method has the analytic advantage that such groups (such as butchers, bakers, etc.) could represent relatively homogenous[2] exposure to occupational conditions. For the most part existing studies in this tradition appear to have been motivated by public concern focused on single occupations suspected to be at risk, for example: aircraft executives (Chadwick et al, 1979), air traffic controllers (Rose et al, 1978), tax accountants (Friedman et al, 1958), auto assembly workers (Timio et al, 1977), and bus drivers (Aronsson, 1980). In these

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[2]Such homogeneity could be argued for guild-like occupations (i.e., those with apprenticeships, unions, etc.) and the three digit U.S. census occupation codes list many such occupations among its 441 codes. However we would argue that the broader (two digit-twelve category) classifications used in the vast majority of studies, such as "manager/professional," or "operative," are definitely not homogeneous.

studies CHD risk indicators are generally investigated rather than CHD incidence itself, because of the very large sample size necessary for CHD analysis.

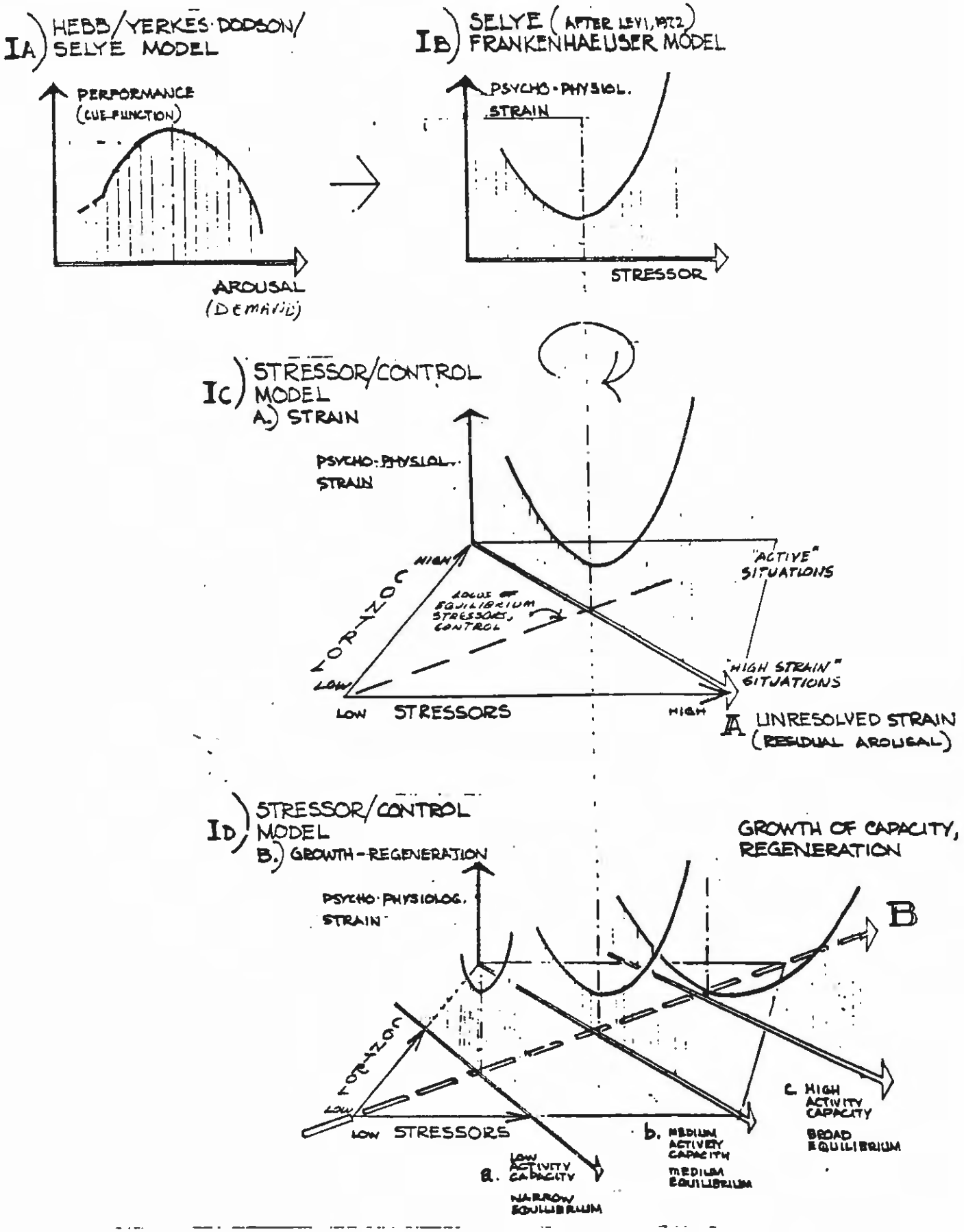
For several reasons these single occupation studies have produced a wealth of interesting observations but an inconclusive analytic understanding of CHD. First, baseline measures on the risk indicators at the national level often do not exist in sufficient detail (broken down for example by age, sex, job tenure; or with information on expected deviations from the means under various conditions) to allow unambiguous identification of single occupations as being at high risk. Second, systematic comparison between occupations on the dimensions of occupational experience which cause the CHD risk are rarely made either in prospective studies or controlled experiments. Thus there is presently little understanding of either the existence or the source of inter-occupational variations in CHD incidence. The absence of detailed data on job characteristics in any of the major U.S. prevalence or incidence studies may reflect the relatively low priority presently accorded to job-related causes of CHD. This lack of detailed job data on the major prospective studies of CHD makes the research task very difficult in this area.

If job induced psychological stress is to be the etiological mechanism for CHD then we need precise environmental models of social and psychological job characteristics that can explain the causal sequence leading to occupational illness. This sequence of effects should include the prediction of mental strain symptoms and other affective responses (job dissatisfaction) from "objecive" work situations, and conclude with psychologically-induced physical pathologies which, in turn, explain CHD. Separate account also must be taken of personality characteristics and demographic factors that could indeed influence the workers' responses to "objective" job conditions. Because of a lack of such differentiated sub-models in stress research there are few guidelines for the development of an inventory of job factors to be investigated; for an understanding of potential aggravator/suppressor effects, or for an understanding of important subpopulation boundaries. We address this lack in the next chapter by attempting to develop a new model of the

job's stress-related consequences.

Figure 1

DIAGRAMS IIa, IIb, III, IV



II. TOWARDS THE DEVELOPMENT OF A NEW MODEL OF JOB-RELATED STRESS AND CARDIOVASCULAR ILLNESS

A. PSYCHOLOGICAL AND PHYSIOLOGICAL MODELS OF STRESS-RELATED ILLNESS

Physiological models of stress response have been primarily formulated as one dimensional models. The organism's response was a function of environmental stressor exposure. In early work such as Cannon's (1914) the organism's reactions of fear, pain, or rage, were proportional to the magnitude of environmental threat. While either a "Fight" or a "Flight" reaction might occur, the same mobilization of physiological resources was hypthesized to be required for each. Selye's General Adapatation Syndrome, (1963) extended the generality of the environmental response model, but retained the same underlying structure: i.e. physiological stress could result as a non-specific response to a wide range of stimuli. In Selye's refined model (Selye 1976, Levi 1972a), the association between stressors and response became "U - shaped" instead of linear: excessivly high or low stress levels could produce undesireable phenomena in the organism; see also Frankenhaeuser et al, (1971) (Figures Ia and Ib).[3]

Mason (1968) has challenged the one-dimensional stress concept and emphasized the complex physiological balance between energy-providing "catabolic" processes and regenerative "anabolic" processes. We will attempt to pursue Mason's line of reasoning by specifying additional environmental characteristics which interact with stressors so as to exacerbate or

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[3]More recent research has further documented the physiological costs of low stimulation in terms of increased catecholamine secretion (Levi 1972b, Frankenhaeuser and Johansson 1974, O'Hanlon 1981). These hypotheses have logical correlates and direct counterparts to models predicting performance, based on environmental stressors, (Figures IIA and IIB). In the Yerkes-Dodson Law, (Yerkes and Dodson 1908, Broadhurst 1959) task performance is associated with level of arousal, and in Hebb's formulation, (Hebb 1955) an inverted U-shaped function (also used in the represeation of the Yerkes-Dodson Law), links "cueing function" to the arousal response. The association between stressors and arousal is seen as direct by Welford (1976), but questioned by Frankenhaeuser and Lundberg (1977) in relation to background stressors.

amelioriate their effects[4]. Environmental stressor moderators, which are generally assumed to arise independently of stressors, present an avenue for reorganizing the unidimensional environmental stressor conception: decidedly different physiological reactions may occur as an organism faces a stressor, depending on whether or not moderating strategies are available. Commonly investigated environmental moderators are social support (LaRocco, House and French 1980) and decision latitude when facing stressors (Karasek 1979a, Frankenhaeuser 1980). McGrath (1970) has emphasized personal resources as moderators to the final strain reaction to a stressor. This latter individually oriented approach, however, does not provide as clear a categorization of the environmental influences of physiological function, which is our subject in the present research.

Recent model elaborations involving combinations of "stressors" and "moderators" further differentiate this more complex stress mechanism. Evidence has been accumulated by Frankenhaeuser (1980) that the combination of environmental moderators with psychosocial stressors in human subjects can lead to dissociated functions of the adrenalmedullary and adrenal cortical systems. (This may be related to anabolic vs. catabolic dichotomy above and is disscussed in Appendix I.) Typically, when fast work pace is coupled with low control, cortisol and adrenaline secretions are elevated, whereas in a

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[4]The two-dimensional theory also has limitations in its present form: the inability to classify the activities of certain endocrine and cardiovascular mechanisms as simply anabolic or catabolic. Growth hormone, for example, serves as a catabolic hormone during conditions of starvation (Roth et al 1963, Mark and Howorth 1965). Furthermore, some hormones may be associated with catabolic responses although they are not energy providing per se, and thus do not relate in a simple way to the hypothesized environment - activity categories outlined earlier. An example of this is aldosterone which serves the function of preserving the plasma volume in the cardiovascular system by retaining water and sodium when blood loss or thirst threatens the body. Unfortunately, it also facilitates the development of hypertension and affects the intracellular electrolyte balance unfavorably (Tan and Murlow 1980, Liddle 1979, Young annd Guyton 1977, Henry et al 1974). Also it is known that in normal individuals, cortisol, a catabolic hormone, supresses thyroxin secretion, (also catabolic) which seems to act here to supress an excessive catabolic response, (Harris 1955, Brown-Grant et al 1954).

situation where the subject has a controlable and predictable stressor, cortisol secretion is low and adrenaline secretion alone is elevated (Lundberg and Frankenhaeuser 1978). This observation was repeated in a study by Rissler and Elgerot (1978). Cortisol secretion may represent a classic high strain psychological phenomenon (Selye 1936), whereas adrenaline secretion, when accompanied by a quick return to baseline levels, may be associated with an "active" behavior pattern that is perfectly healthy, indeed even health enhancing (see Appendix I for further physiological discussion).

A brief review of the voluminous literature on job-related mental strain and dissatisfaction reveals the dichotomy in research approaches that is also reflected in studies of physiological stress correlates. Two survey research traditions have emerged, each addressing a different problem, and each applying models that explain only a portion of the process of job strain development. In one tradition, the research has focused on job decision latitude (decision authority or skill level) and other research within this same tradition has focused on "stressors" on the job (or job demands such as work load, conflicts). Unfortunately, job decision latitude research rarely includes systematic treatment of job demands, and job stressors research rarely includes systematic discussion of job decision latitude impacts. Most of the vast literature on job satisfaction, for example, focusses on job decision latitude alone (Gardell 1971, Turner and Lawrence 1965, Walker and Guest 1952, Hackman and Lawler 1971). The other research tradition, the "life stress" tradition, focuses on the mental and physical illness induced by environmental stressors. Although most of this work has not dealt explicitly with job stressors (Langner and Michaels 1963, Holmes and Rahe 1967, Singer et al 1976, Dohrenwend and Dohrenwend 1974, Berkman, 1971), some recent studies have included this (Theorell 1976, Caplan et al 1975, Quinn et al 1971). The range of decison alternatives available to the person facing the stressor is rarely discussed in the literature (Dohrenwend and Dohrenwend 1974). We suspect that many contradictory findings in the literature can be traced to incomplete models derived from these mutually exclusive research traditions.

B. THE JOB STRAIN MODEL

There is, at the very least, a need for an "interactive" model, one which can examine the combined impacts of job demands, job decision latitude and other moderators. Our initial model postulates that psychological strain (and in the second stage, physiological strain) results not from a single factor, but from the joint effects of the demands of a work situation and the range of decision making freedom (decision latitude or control) available to the worker facing those demands. These two aspects of the job situation represent, respectively, the instigators of action (job demands or stressors which place the individual in a motivated or energized state of "stress", or arousal) and the constraints on the alternative resulting actions which make use of the energy. The individual's job decision latitude is the constraint which modulates the release or transformation of "stress" (potential energy) into the energy of action. If no actions can be taken (Ziegarnik, 1927), or if other desires of the individual must be foregone because of low decision latitude (see discusssion in Henry and Cassel, 1969 p. 179), the "unreleased" energy is what we call psychological strain. This psychological strain may manifest itself internally, as psychological or physiological strain symptoms. On the other hand, natural, self-regulated actions expand the potential energy (physical exertion or mental activity) and there are no such deleterious results—and, under appropriate circumstances, (see Appendix I) growth of capacity for action may occur.

Social relationships may be understood as a second analytical level added to this model. Social relationships are hypothesized to expand or contract the individual's capacity for managing stress (potential energy for action). Individuals who are "socially integrated" link together their capacities for accommodating stress. This allows mutual levels of "stress" to equilibrate between individuals of temporarily different environmental situations. This equilibration of stress among group members is defined as "social support

buffering" in our analysis.[5]

The term "stress" (arousal or potential energy) will not be used thereafter, because it is not directly measured in the present research. Instead we define three related terms. The first is an independent variable measuring stress sources present in the work environment such as work load demands. These are termed "psychological job demands" or "job stressors." The second independent variable measures "job decision latitude" or "job control." We predict that the unmeasured composite of these two measures, job induced psychological strain, is related to psychological stress symptoms (Karasek, 1979a), and to our dependent variable in the present study, cardiovascular disease.

Figure 2 summarizes in a simple manner the types of jobs that might result from different combinations of psychological job demands and job decision latitude (Karasek, 1976). The situation along the diagonal ("A"), when demands are relatively greater than discretion, ("the high strain job") is of primary importance for this paper (the implications of the second diagonal 'B' - for active growth and regeneration are discussed in Appendix I). The utility of this model is based on the distinction between two broad types of job characteristics: job demands and decision latitude. Ideally, these two aspects of the job should be highly correlated: "authority is commensurate with responsibility", according to conventional management wisdom. In fact, there is considerable empirical evidence that the

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[5]Methodologically, social support buffering should reduce the strength of association between task characteristics and strain symptoms, independently of the direct effect of the level of social support on the level of strain symptoms. This implies that buffering will exist even if social support actually increases strain in some situations. For example, when an individual's own environmental stressors are low and social cohesion is high, the individual would serve as a sympathetic ear for the problems of his more strained coworkers and "absorb" part of the problem. The work group, if socially cohesive, serves as the reservoir fo moderating the strain of any of its members and equilibrating individual differences in strain.

correlation is quite low (Karasek 1978a), which implies that there are substantial groups of workers with discrepant demands and decision lattitude[6], i.e. low control in the face of high demands. [Using the three Q.E.S. surveys together, r= 0.08; using roughly analogous dimensions in Swedish national data, the correlation is 0.27 (Karasek et al, 1981); in a Swedish white collar sample, r= 0.07 (Karasek, Lindell, and Gardell, 1982); and r= 0.05 in a white collar German sample (Benninghaus, 1981).] Other evidence for the model is presented on pages 15-18, and in Appendix I.

The two dimensional hypothesis predicts that exposure to environmental stressors may lead to two outcomes: either pathology or growth and regeneration (Appendix I).

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[6]The difference in the type of effect on the psychological strain of these separate dimensions (job demands and job decision lattitude) implies that major errors in hypothesis testing may be made if the distinction between them is not made. Some authors mix the concepts job demands and job discretion interchangeably (Hulin 1971, French and Caplan 1970). Others consider such measures as the possibility of making decisions or the opportunity to use skill to be job demands instead of decision lattitude (Ritti 1971). In both cases the risk is clear; elements of the job situation which may have different effects are mixed together. Indeed, we hypothesize below that opportunities to use skill and make decisions reduce the undesirable effects of job demands. If our hypothesis is correct, then studies which add these two types of measures together would find most of the significant relationships either cancelled out (Blood and Hulin 1967) or inconsistent if non-linear and interactive relationships exist between job demands and job decision lattitude (Karasek 1978b), or understated if only one potential contributor of several is examined (Karasek 1978b).

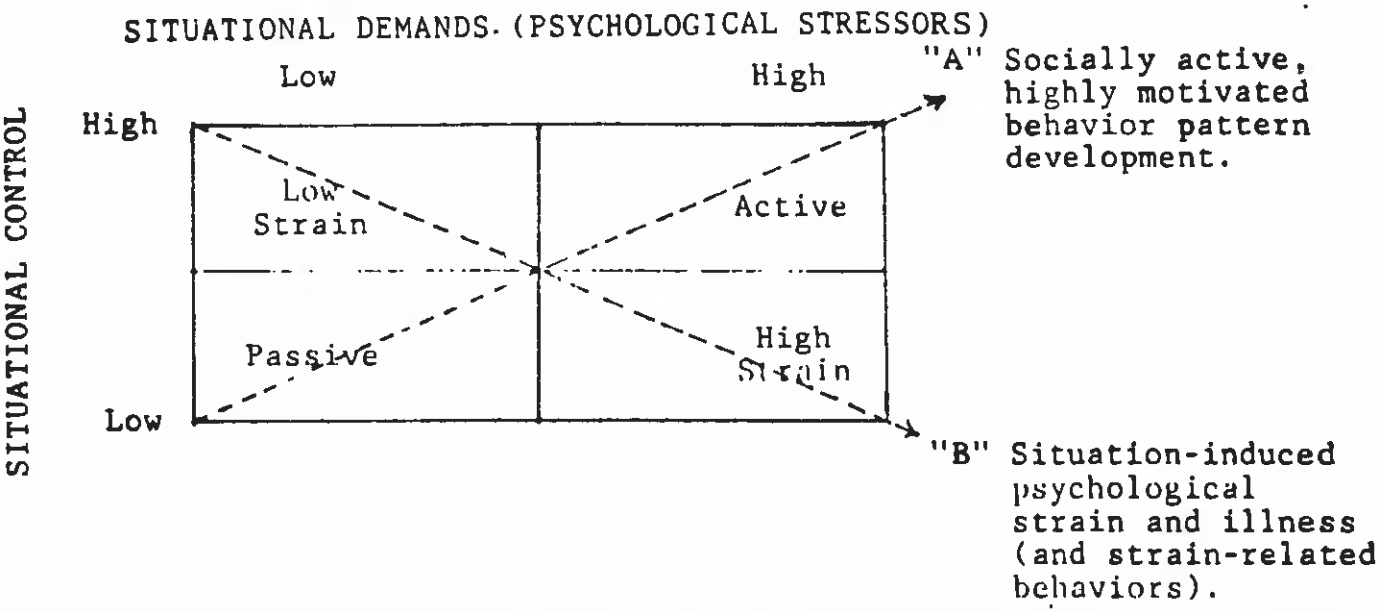

Figure 2 - SITUATIONAL STRAIN MODEL

The degree of control the individual has[7] in coping with the stressors, along with the degree of the stressor itself, simultaneously determine the outcome. How does this model compare to the General Adaptation Syndrome of Selye (1936) which forms the basis of much of contemporary stress physiology? The limits under which Selye's theory holds may be better defined using our two dimensional theory. Selye's "eustress" and "dystress" distinction proports that a certain amount of stress is considered "good" (possibly, even growth promoting) whereas too much stress or stress under less favorable (but unspecified) conditions represents "dystress" and results in pathology. The level at which stress switches from "good" to "bad" is poorly specified in Selye's theory: one can determine that the stress was "too much" only if it produced "bad" consequences. However, our two dimensional theory explicitly names a contingent condition which determines whether "good" or "bad" consequences will result from stressor exposure: the individual's control over the situation which he perceives as the stressor. Translation between the two dimensional model and Selye's single dimensional model is then possible, (Figures 1A and 1B). Selye's arousal (or stress) continuum is equivalent to the resultant dimension of the two dimensional model, "unresolved strain", (or residual arousal), Figure 1C, Diagonal A. This represents the difference between stressors, and control possibilities; (stressors exceed control possibilities moving into the corner near label A). Individual control over stressors was a dimension not incorporated in most animal studies. At high levels of demands and low levels of control the two dimensional theory and

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[7]A limitation of our theory concerns the individual's own mechanisms of perception, interpretation, and integration of environmental experience which may significantly mediate or determine the resulting physiologic response. Our theory is based on dimensions of the environmental situation, not upon dimensions of individual response. The theory thus delineates the environmental contribution to stressful individual states and perceptions of control. Any comprehensive theory of individual - environment interaction must also account for the refinements contributed by the effects of individual perceptions, and the forces instrumental in shaping them. A discussion of these mechanisms at present, however, is beyond the scope of this paper (Karasek 1976). One classic discussion of the significance of this factor has been made by Lazarus (1966).

Selye's theory achieve parity and yield the same expected result: physiological and psychological stress, and possible disease. Control over the stressor by animal subjects was fixed at a constant low level in Selye's basic cardiovascular pathology experiments. However, this dimension can be varied in the two dimension model, which will simultaneously determine the "good" or "bad" consequences of stressor exposure.

A further predicton of the Selye model is a range of highly motivated "optimum activity" or "optimal performance". "Optimal activity" is defined somewhat tautologically as occurring in the middle range of Selye's stress continuum. The two dimensional model also specifies conditions for highly motivated, or "optimal" activity: when levels of demands and levels of control are matched. Here, strain and regenerative mechanisms are in balance, allowing optimal function. It may be inferred from this theory that the peak level of optimium activity increases as a function of the level of the stressor/control match or "equilibrium". This is illustrated in Figure 1D, a graphic representation of growth and regeneration, that is increased capability to adapt to environmental challenge and risk. Additionally, Welford (1976) and Fiske and Maddi (1961) have observed that at higher levels of stressor/control match or equilibrium, optimal activity occurs over a broader range, (i.e., there exists a larger number of alternatives to draw from in dealing with the stressors), than at lower levels; Figure 1D, curve C compared with curve A, (for more discusssion of the mechanism of growth and regeneration, see Appendix I).

C. FINDINGS CONFIRMING THE ASSOCIATIONS BETWEEN THE JOB STRAIN MODEL, PSYCHOLOGICAL STRAIN AND CHD

1. The Job Model and Psychological Strain

The Job Demand-Job Decision Latitude model to predict psychological strain consequences of job characteristics described in Karasek (1979a) has been tested by other researchers with other data bases and supplementary dimensions. Karasek, Triantis, and Chaudhry (1982) found that socio-emotional

and instrumental social support "buffered" the association between the job characteristics and mental strain (i.e., the association is weaker with social support) for male workers in the 1972 U.S. Quality of Employment Survey (N=1000). Similar findings confirming both the job demand-job control model, and the buffering effect of social support was found for 10,000 male and female white-collar workers in Sweden (Gardell 1971). Support for an interactive effect on psychological strain between demands and control was found be Broadbent and Gath, (1981). Turner (1980) found support for the job strain model for 1500 mortgage loan clerical workers in 70 savings and loan banks. He further found that ease of obtaining assistance from coworkers was a crucial intervening process. Freeman and Jucker (1980) found clear support for the job strain model for 2600 workers in three manufacturing assembly plants of a major firm. Ebeltoft (1980) reported consistent findings with the job strain model for backache symptoms for Norwegian workers. Consistent findings for 5000 Finnish workers were reported by Kauppinen-Toropainen (1981). Goiten and Seashore (1980) of the Institute for Social Research at the University of Michigan confirmed predictions of the job strain model using recent 1977 Quality of Working Life data, and also found further support for the active-passive dimension of the job demands-job control model, (see also Benninghaus, 1981).

2. The Job Model with Respect to Endocrine and Metabolic Reactions, and Cardiovascular Functioning

The urinary excretion of catecholamines has been recorded in several field investigations of job stress, (Friedman et al 1960, Elmadjian et al 1958). Increased excretion has been observed when job demands increase such as during periods of overtime work (Risler and Elgerot 1978), when piece wage replaces regular salary (Levi 1972b), and when rushed tempo is combined with lack of control (Johansson, Aronsson and Lindstrom 1978). Plasma catecholamine levels have also been observed to rise when a subject is exposed to long term situations of rushed job tempo and concomitant lack of control (Zorn and Seiferet 1977, Anisman 1975, Frankenhaeuser 1976, Euler and Lundberg 1954), particularly when he shows signs of the "coronary prone" (rushed, dissatisfied) "Type A" behavior (Friedman et al 1975, Simpson et al 1974).

Cortisol, both in urine and plasma, has been followed in several field investigations of job stress, particularly in situations of low control or low predictability (Vernikos-Danellis et al 1975). For instance, in the studies of Timio et al (1977) the plasma cortisol levels were observed to be higher in workers who had a combination of assembly line jobs and piece wages than in comparable workers with other job designs. This difference remained in workers who became accustomed to the job design during a six month period. We have not been able to find published field studies of anabolic hormones in job stress conditions.

Several field studies have been published which throw light on the balance between catabolism and anabolism in relation to carbohydrate and lipid metabolism as well as upon electrolyte changes in the blood. Blood levels of triglycerides rise during conditions of increasing job demand (Carlson, Levi and Oro 1972, Taggart and Carruthers 1971, Friedman et al 1964, Taggart and Carruthers 1977). There is some indication that high density lipoprotein cholesterol blood level is being depressed during conditions of increased job demand (Chadwick et al 1979). Serum uric acid and potassium levels rose during a period of night work for railway workers, previously unaccustomed to shift work (Theorell and Akerstedt 1976). Both of these reactions may be indications of increased catabolism. New field techniques which utilize nuclear magnetic resonance (Chance et al 1980) promise to allow additional, and more discrete measurement of cellular metabolism of working individuals non-invasively.

Heart rate and blood pressure variations during field studies of work activity have been recorded in several published studies (Redwood et al 1976, Golding et al 1973, Coronary Drug Project 1973, Simonson 1971, Chiang et al 1969). The observations in general, verify that increased demands particularly in combination with low control, give rise to increased heart rate and blood presure (Taggart and Carruthers 1971, Risler and Elgerot 1978). Electrocardiographically recorded arrhythmias, other than abnormalities in heart rate, have not been systematically studied in relation to varying job design, but certain types, (e.g. ventrcular premature depolarizations), have

been shown to be elevated during the working day (Orth-Gomer 1979).

3. The Job Model and Epidemiological Evidence of CHD

Karasek et al (1981) found associations for male workers in nationally representative Swedish surveys between low control and high demands at work and high prospective risk of cardiovascular/ cerebrovascular mortality using a case control technique and an indication of elevated prospective incidence using a mortality validated indicator of CHD. Specifically, a hectic and psychologically demanding job increased the the risk of developing CHD mortality indicator and premature CHD-CVD death. Low decision latitude--expressed as low intellectual discretion and low personal schedule freedom--is also associated with increased risk of cardiovascular disease. Low intellectual discretion predicted the development of the CHD mortality indicator, while low personal schedule freedom among the majority of workers with the minimum statutory education increases the risk of CHD-CVD death. The associations existed after controlling for age, education, smoking, and overweight. Alfredsson et al (1982), using a similar model and a case control technique with a large sample of myocardial infarctions from the Stockholm area (334 cases and 882 controls) found a consistent pattern linking prospective CHD and job characteristics estimated by occupational title (similar to our methodology in this report). Shift work and monotony were associated with significant excess risk. Hectic work was not associated with excess risk by itself but, <u>in combination</u> with variables associated with low decision latitude and/or few possibilities for growth, it was associated with significant excess risk.

D. PHYSIOLOGICAL PATHWAYS FFROM JOB TO CHD

A summary of how these physiological mechanisms predict CHD is organized

into simplified hypotheses in Figure 3[8] (see Appendix I for more detailed discussion). For the purposes of our research we identify two primary mechanisms of coronary heart disease: an atherosclerotic process and an acute stress process. Both are probably involved in acute cardiac events such as myocardial infarction and sudden death which account for 50% of CVD death, and indeed may well be involved in chronic CVD manifestations as well. The atherosclerotic process is a very long term chronic deterioration of arteries (particularly coronary arteries) involving occlusion and a loss of elasticity. Atherosclerotic development probably cannot be detected by the relatively short term research although derivative aspects of health status (as reflected in blood pressure, ECG, cholesterol levels) should be measurable. The acute stress mechanism however, which may have both short and long term effects on CHD, should be particularly strongly affected by the work environment factors which could be detected even in short term research. Three major mechanisms are involved in the acute stress pathway to CHD/hypertension induced by "high strain" work environments: arousal-neuroendocrine responses, cardiovascular responses, and catabolic metabolic responses.

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[8]An independent set of secondary, exploratory hypotheses relates to the physiological processes of growth and regeneration which may reverse the CVD disease process, repairing cell tissue and restoring normal system response patterns to environmental stressors. We hypothesize that "active" and possibly "low strain" job situations promote such processes. Here we expect that both regenerative-endocrine responses are the physiologically relevant mechanisms. {see Appendix I for further discussion}

III. A JOB CHARACTERISTICS SCORING SYSTEM FOR OCCUPATIONAL EPIDEMIOLOGY

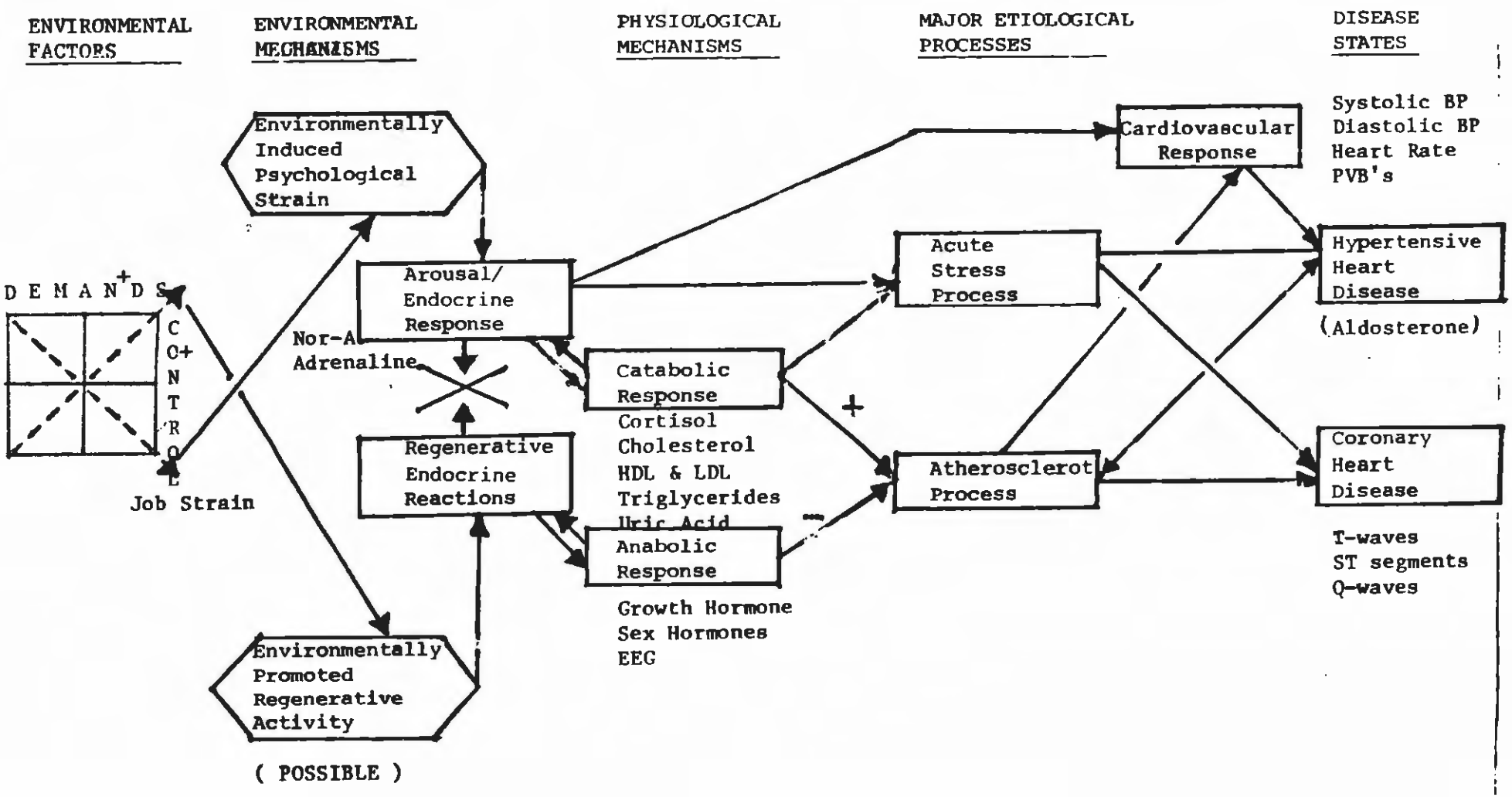
In this chapter we describe development of a job characteristic scoring system for predicting the health correlates of job activity more precisely than occupational status scales. The system generates fourteen dimensions of work activity for any individual whose job title and industry are known using the U.S. Department of Labor surveys of the full U.S. work force in 1969, 1972, and 1977. Respondent reports about their jobs are first averaged for the U.S. Census 1970 occupations. For males, 211 occupations, representing 95% of the work force, can be scored in this manner. In a second stage of analysis, additional precision in the scores is generated by adjusting the scores for the individual's age, race, marital status, region, and self employment. For a discussion of general issues relating to development of a job characteristic dimension systems and related literature review, see Appendix II.

A. DEVELOPING A NEW METHODOLOGY FOR ANALYZING JOB CHARACTERISTICS OF OCCUPATIONS

1. Job Dimensions Vs. Occupational Categories

The simplest system for occupational analysis would involve categories. The use of such a system would then merely require specification of job title, and table search would allow "determination" of all job attributes. Is there a set of "irreducible" occupational categories (butchers and bakers, etc.) that could form a non-arbitrary set of building blocks for such a system? One theoretical perspective would answer "yes" and hold that such occupations would be like "guilds" or similar groups with unique social reality (at some level of aggregation). Supporters of this perspective would claim that the observed variation within any occupation is relatively inconsequential, possibly due to individual variation among workers. The source of this occupational homogeneity could be labor market allocation mechanisms (which could only create a finite number of markets) or a finite number of institutional structures for apprenticeship and career development. Further, historical norm-building processes can consolidate similarity of experience by enforcing common attitudes toward equitable performance and advancement, and developing group identity and common political and social orientations. A

Figure 3 LINKAGES BETWEEN WORK ENVIRONMENTAL FACTORS AND PHYSIOLOGICAL MECHANISMS LEADING TO C.H.D.



problem of the category approach, however, is that when occupational groups are used for analytic purposes, it is the implied "dimension" differentiating the categories which is used to draw generalized conclusions (i.e., "exploitation" level using even the two categories in Marxian analysis). Indeed, even the twelve categories of the two-digit U.S. Census codes are often used as a "status scale" from "managerial/professional" to "laborer," (possibly excluding farm workers, Goldthorpe and Hope [1974])

A second analytic perspective would argue that dimensions are preferable to categories for sophisticated analyses of job structures. Supporters of this perspective would maintain that in today's complex economy the number of categories needed to capture the true diversity of job experience is enormous. While relative job homogeneity might occur at some detailed task level, this level would imply far more categories than even the 441 three-digit U.S. Census occupation codes (where all "bakers" would be put into the same category). It would be more practical to speak of measuring job dimensions, and locating occupations as points in a multi-dimensional space of job characteristics. As evidence of the necessity of speaking of job dimensions, representatives of the "dimensional" perspective would allude to historical changes in task experience, even within occupational groups, such as the "deskilling" observed by Braverman (1974) or transformations of occupations by technology (e.g. typesetters by computerized data in the 1970's; weavers by the spinning mills of 1830's (Thompson 1963)). They would point to task design strategies which drastically changed the nature of work, often without changing occupational boundaries, such as Taylorism in the 1920's (Galbraith's "new" bricklayer or Taylor's "new" machinist) or the Quality of Working Life Movement with its goals of "enriching" or "enlarging" tasks. They would allude to within-occupation differences, for example, in experience between two "bakers" -- one making croissants for a sophisticated French bakery shop and the second working a bread-slicing machine in a Wonder Bread factory. All of these within-occupation differences, they would claim, require detailed dimensions of work activity to monitor. Unfortunately, the dimensional system is also confronted with problems, the most severe being the vastly increased research resources that must be expended for job dimension research. Individual work settings must be examined in large numbers for each analysis (as opposed to only once for a category system, which can then be referenced

through job title alone). Equally problematic is the fact that no consensus yet exists as to an appropriate set of job dimensions that span occupational experience for a variety of research purposes, (our issue p.__). Furthermore, dimension advocates might concede that occupational categories do aggregate a great deal of variance in job characteristics "efficiently." A category offers a "gestalt" of easily remembered, if diverse, information about the circumstances of each occupation. This picture may even supply information on unmeasured dimensions that would otherwise require additional surveys to measure, and indeed there is no guarantee that the unique occupational social reality can be measured by any set of task dimensions.

The approach taken for our system will be to emphasize job dimensions over occupational categories, although in practice the system combines features of both approaches - as does the DOT. We develop a set of job characteristic scores that can be used to measure differences in job situations between individuals - based on Census occupation categories. This choice reflects our feeling that variations between occupations yield more analytic understanding than categories alone. However, application of the system is made vastly simpler if job differences may be merely inferred from the occupational title instead of requiring detailed on-site measurement of job characteristics (see p.__ for caveats about this methodological approach). We can use the "mean" scores on job characteristics by occupation gathered in national survey data to create such a system. A major advantage of such group level data is that it allows us to avoid problems of individual self-report bias and shared method bias inherent in questionnaire data since we relay on the occupational group's consensus about typical job characteristics. However, the primary assumption we must make is that meah job scores really <u>do</u> vary substantially between occupations (the assumption also made by the DOT), so that by specifying an individual's occupation code, useful information about an individual's job can be determined. To develop the system requires two elements: first, a set of occupational categories, widely accepted by researchers, and widely available in present data bases -- U.S. Census Occupation Codes. Second, an empirical data base is required. In the sections below we describe the data base, the resulting dimensions, their reliabilities and their between occupation variance, validation analyses and their effectiveness in predicting outcomes in comparision to conventional

status measures and individual level job data.

2. Occupational Codes

We base the occupational categories on the U.S. Census occupation codes, which provide 441 categories at the detailed three-digit level. These occupational codes reflect, to some degree, the "social reality" of occupational experience in terms of "guild-like" associations, union activity, training and career pathways, and represent task categories similar to those used for promotion and evaluation within organizations (albeit at a coarse level, see Spilerman 1977). The major advantage of using the Census codes is that coding materials for translating job titles into Census codes are readily available (U.S. Bureau of the Census, 1971) and these Census codes are also available on major U.S. government commissioned surveys in the fields of health, labor market activity, and productivity analysis. Our system will further utilize two other pieces of information that are also usually readily obtainable in major surveys. The U.S. Census three-digit standard industry codes (S.I.C. codes) are used to break down several occupational codes with large populations (e.g., managers, census code 290, are 11.9% of the male work force) into five to ten industry subcategories. Self-employment is also used to further subdivide managers. Because of sample size limitations, and because almost 200 of the occupation codes refer to occupations representing less than 0.1% of the male work force (or .2% of the female workforce), we consolidate many of the smaller occupational codes. The result is that approximately 240 codes are scored for men and for women.[9] The final codes are listed in Appendix II.

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[9]We attempt to consolidate codes when there is some obvious similarity between two small occupational groups (e.g., geologists, marine scientists, physicists, and astronomers), because doing so allows us to estimate a category mean that is based on more than one or two individuals. Some occupations are both small and unique, however, and cannot be consolidated. Thus no reliable scores can be generated using our Q.E.S. survey data base for 2% of males and 8% of females (females in small, primarily male, occupations are likely to be unscorable).

3. The Job Characteristics Surveys: The U.S. Quality of Employment Surveys

A major practical problem in developing job characteristics scores by occupation is to find an appropriate data base. A large national random sample of individuals, which gathered detailed job data would allow the true national distribution of job characteristics to be modeled (a problem for the DOT). Unfortunately, few data bases exist with the range of job characteristic information, which also have sufficient sample size to support precise estimates for all 440 Census codes. Census tapes do not contain job measurements in sufficient detail[10]. The largest national survey of detailed job characteristics known to us is the combined sample of individuals surveyed for the U.S. Department of Labor's (conducted by University of Michigan's Institute for Social Research) Quality of Employment Surveys 1969, 1972, and 1977 (Quinn and Staines, 1979). The primary goal of these three surveys was to estimate the frequency of job-related problems at the national level and to allow time trends in job characteristic change to be analyzed. The surveys are nationally representative of the working population and contain a total of 4531 respondents. (The breakdown is as follows: in 1969, the survey contained 993 males and 540 females; in 1972, there were 985 males and 470 females; and in 1977, the survey included 968 males and 547 females.)[11] All respondents working at least 20 hours per week, between the ages of 18 and 65 were chosen from randomly sampled U.S. households. Another advantage of this data base is its familiarity to other researchers and its use in a large number of previous studies (see Quinn and Staines, 1979).

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[10]While a tape does exist that has merged the DOT job characteristic data and Census codes (n=60, 441; see Spenner, 1980), its DOT job measurements are inferred, not measured.

[11]Our sample is analyzed unweighted. While the 1969 survey is self-weighting, weights are available for the 1972 and 1977 samples to correct for different numbers of working individuals per household. The weight factors (integers 1, 2, 3, according to the number of employed persons per household) are judged capable of introducing an unstable source of variation within our small occupational groups (n as low as three) and are therefore not used. Although this could have slight effects on the national representativeness of our samples in 1972 and 1977 (the weighting changes are not major), analysis by Quinn and Staines (1979, pp.8-13) show most weighted distributions to be similar to the unweighted distributions.

4. A System of Job Dimensions

One method for delineating a system of job dimensions is to review the literature for existing scheme for categorizing job characteristics. Several previous examples of job dimension frameworks exist, which have been used in both research and task redesign purposes. Kohn and Schooler (1973) have a comprehensive list of four major categories: organizational locus, occupational self-direction, job pressures, and uncertainty. However, their list includes few measures of physical stressors, and no measures of social relationships. Karasek (1976) proposes a set of five major dimensions to predict many health outcomes: psychological job demands, intellectual discretion, schedule freedom, and two physical stressor measures. These dimensions are derived from factor analyses of the Swedish National Level of Living data (Johansson 1971), but again, measures of social relations at the work place do not appear. The major framework presently used for job design strategies, Hackman and Oldham's (1976) motivating potential score, is based on dimensions of autonomy, variety (skill discretion), feedback, task identity and task significance, - but here both psychological and physical stressors are omitted - as well as most micro level social relationships. Another example of a very comprehensive system of job data is the Dictionary of Occupational Titles (DOT), which combines task dimensions relating to skill requirements and aptitudes with an extensive set of occupational categories. Each occupation (of 12,099 for the third edition 1965) is identified by a nine-digit code, including an industry based classification type[12] ; a code for complexity of work with respect to data, people and things; and a unique identification number. In addition, information is supplied on 41 "worker traits" representing aptitudes, temperaments, and interests necessary to do the job, and on a variety of working conditions (Cain and Treiman, 1981), although methodological irregularities limit the precision of inferences that

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[12]The DOT's concentration on industries which produce "things", is an advantage for another job characteristic inference system which is roughly based on DOT occupations. The Harvard University School of Public Health system for inferring toxic chemical exposures (DOT classes are linked to reference tables of occupational chemical hazards) probably gains from the detailed breakdown available for these physically hazardous occupations (Hoar, et al, 1980).

can be drawn from the data.[13] A factor analysis of these measures reveals factors for task complexity, autonomy (plus control over others), physical demands, hazards (plus additional dimensions on manual and interpersonal aptitude) -- but no psychological load factor.

Data in the QES do not allow for some detailed job content areas listed in our "ideal job dimension system" (see Appendix II - Figure A-1) to be well estimated, even with 4500 respondents. For example, exposure to toxic chemicals typically affects very small occupational groups and thus is missed by national surveys. Also, one of our four major outcome categories in Figure A-1, macro social behavior at the community or plant level is not well measured. A major practical constraint in developing dimensons with the QES samples was finding questions sufficiently similar across the three surveys to maintain our sample size. For a few dimensions, similar question "content" was matched across surveys in spite of detailed question differences (content was confirmed by factor analyses in each survey, then standardized scores

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[13]The DOT was originally developed to assist job/person matching in the labor shortage periods during and after World War II, and describes jobs in terms of specifiable skill requirements and aptitudes. Although over 12,000 occupations are listed, in reality, all of the worker traits and task complexity data is consolidated into 114 job categories "homogeneous in terms of abilities and traits required of workers" (U.S. Dept. of Labor 1966, p. , Sainty 1974, Broom et al 1977). One significant problem with the DOT is the irregularity of the empirical methodology used to obtain the job characteristic information (Miller et al, 1980). Another problem is that the job estimates are based on only one (or no) direct job measurement for 45% of the occupations and on no more than three job measurements for 72% of the occupations. Furthermore, the majority of occupations are selected from the manufacturing industries (67% versus 32% of the U.S. labor force) - with large manufacturing firms predominating. Few occcupations are selected from the trade and service industries (16% versus 32% of the U.S. labor force). A further problem with the DOT is that no demographic information on the worker is present in the job analyses, so characteristics of the worker that may affect either job incumbancy or the actual working conditions cannot be ascertained. The irregularity of the data gathering techniques also means that no information on the reliability of the job characteristic scores is available (Cain and Treiman, 1981).

across three surveys were combined - see Appendix IV for further detail[14]). Below we discuss the job characteristics that are developed from the questions available in these three surveys (a decent, but hardly perfect fit of theoretical goals outlined in Figure A-1). Detailed question wording and scale construction parameters are presented in Appendix I.

I. Decision Latitude (Control)
   - A. Skill Discretion
   - B. Decision Authority
   - C. Total A+B

II. Psychological Work Load
   - A. Work Load
   - B. Hours of Work
   - C. Customer Hostility (see p. 22)

III. Other Psychological Stressors at Work
   - A. Job Insecurity

IV. Social Support at Work
   - A. Coworkers
   - B. Supervisor
   - C. Total A+B

V. Physical Exertion

VI. Physical Hazards
   - A. Noise
   - B. Temperature Extremes
   - C. Hazards and Toxic Exposures

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[14]We first tested to see whether mean scores for the national population had changed significantly between years on two dimensions where questions were exactly the same and time related changes should be observable. The means seemed very close (decision latitude: 37.59, 1969; 37.92, 1972; and 37.99, 1977; S.D. = 6.70, 6.61 and, 6.69 respectively) and thus the decision was made to pool the sample by summing z-scores from each year. Short term variations in the business cycle could be expected to affect, for example, the "job insecurity score" (Brenner, 1971) but we have no reason to believe the relative rankings of job insecurity or decision latitude by occupation have changed drastically from 1969 to 1977.

5. Reliability Analysis

As a source of job measurements, the QES survey excels in its detail, but also has some shortcomings. All measurements are self-report, a particular loss for some physical hazards such as noise measurement. However, we diminish shortcomings of self report data through enhanced possibilities for error assessment (using occupational analysis of variance, see Schwartz, Karasek and Pieper, 1982) and the fact that our occupation-based analysis tends to average out individual response biases (we have "multiple observer" ratings of an occupation's job content). In Table 1 we report reliability statistics about the job dimensions. A first measure of scale utility is an estimate of the between-survey reliability, which uses the between-survey variance of occupation means (based on a nested ANOVA) to extrapolate what the between survey variance would be for individuals. This measure reflects the degree to which our occupational scores should be replicated in other surveys which obtain the same type of detailed job characteristic data. A second measure of reliability reported in Table 1 is the internal scale reliability (Cronbach's alpha) of the individual question responses for each job characteristic scale that is constructed from several indicators (this measure will be less important for our occupational-aggregate system than for individual-level analyses, since the unreliable variance, which is not expected to vary systematically across occupations, should not bias our score estimates). To the degree that one is only interested in variation between occupations, much of this unreliable variance will be washed out. Finally, we report the between-occupation variance (as a percent of the reliable scale variance).[15] This is a vital measure, for it assesses the degree to which our occupational inference system could estimate or reproduce information about individual's job characteristics (within-occupation differences among jobs cannot, of course, be inferred from the occupation's mean score). The correlations between job dimensions, and thus their potential for "spanning" a multidimensional range of job experiences are shown in Table 3 (based on

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[15] We report eta^2 corrected for the large number of degrees of freedom (about 210 occupations in the male sample). This corresponds to the "reproducable" variance and adjusts for the portion of the sample between-occupation variance which is attributable to random sampling variations (total between-occupation variance is therefore higher than our eta^2 statistic).

individual level and occupation level data).

We can also validate the content validity of some of our scales by comparing scores with the DOT for the 1970 U.S. Census three-digit occupation codes. In order to apply DOT scores to census categories, a major population survey containing both DOT and census occupation codes is needed. Such a tape has been analyzed for the third edition of the DOT by Spenner (1980), using some job scores from Temme (1975), which weights DOT job data by their proportional representation in each census occupation category. Spenner's 595 1970 census occupation categories (including industrial subdivisions) are then coded into our smaller set of 211 categories (job data again weighted by size of occupation) for the comparison presented in Table 2. In general, elaborate comparisons are possible in the areas of skill requirements and decision authority, while some comparisons can also be made for hazardous exposures. However DOT data is weak for both physical and psychological workload, and no information is available on social relations. It must also be remembered that the DOT is not obtained from actual survey responses, but from expert's estimates of job qualities (albeit with inconsistent methodologies for a critique of its scales see Miller et al, 1980). In general, agreement appears to be good in the area of decision latitude and some of the hazards.

B. JOB CHARACTERISTIC DIMENSIONS

1. Decision Latitude

We attempt to measure the individual's potential control over his/her tasks and other job-related activities in the work setting.[16] In practice most empirical literature measuring such a control issue reflects a dichotomy between two concepts: authority over behavior (important in hierarchial work structures) and the intellectual skill level required of work performance

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[16]This measure thus differs from the measure of control over others, used to define class by Dahrendorf (1959), and Robinson and Kelley (1979). Obviously the measures are closely connected, but a measure of control as experienced by the individual is a necessary element for the mechanisms involving individual behavior and health, which is the goal of our paradigm.

TABLE 1: RELIABILITY ESTIMATES AND PARTITION OF VARIANCE
QUALITY OF EMPLOYMENT SURVEYS 1969, 1972, 1977

	RELIABILITIES									
		WITHIN SURVEY CRONBACH'S α								
	CROSS SAMPLE	1969	1972	1977	POOLED	TOTAL	BETWEEN OCC. ETA^2	BETWEEN OCC VAR / TOTAL RELIAB.	WITHIN OCC.	TOTAL MEASUREMENT ERROR
DECIS. LATIT.	.952	.686	.697	.723	.702	.668	31.9	47.8	34.9	33.2
- SKILL REQ.	1.000*	.634	.678	.699	.669	.669	33.9	50.7	33.0	33.1
- AUTHORITY	.942	.583	.502	.643	.577	.544	19.6	36.0	34.8	45.6
PSYCH. DEMAND	.862	.632	.593	.619	.613	.528	5.6	10.6	47.2	47.2
HOURS	1.000*	**	**	**	**	1.000	20.6	20.6	79.4	0.0***
JOB INSEC.	.843	.256	.300	.334	.294	.248	9.1	36.7	15.7	75.2
SUPPORT	1.000*	.738	.874	.859	.839	.839	4.0	4.8	79.9	16.1
- COWORKER	1.000*	.474	.779	.779	.717	.717	2.1	2.9	69.6	28.3
- SUPERVISOR	1.000*	.742	.860	.853	.822	.822	2.8	3.4	79.4	17.8
PHYS. EXER.	1.000*	**	**	N.A.	**	1.000	25.8	25.8	74.2	0.0***
NOISE	.960	**	**	**	**	.960	9.6	10.0	86.4	4.0***
TEMPERATURE	.966	**	**	**	**	.966	6.0	6.2	90.6	3.4***
HAZARDS	1.000*	**	**	**	**	1.000	18.0	18.0	82.0	0.0***
(HOSTILITY)	.832	**	**	**	**	.832	18.3	22.0	64.9	16.8***

* ESTIMATED BETWEEN SURVEY UNRELIABILITY NEGATIVE, TREATED AS "0."

** ONE VARIABLE INDICATOR; CRONBACH'S ALPHA NOT APPLICABLE.

*** NO ESTIMATE OF WITHIN SURVEY RELIABILITY SINCE SCALE IS BASED ON A SINGLE INDICATOR.

TABLE 2 VALIDATION OF Q.E.S. JOB DIMENSION SCALES WITH D.O.T. JOB SCALES [correlation coefficients between occupation-level scores from D.O.T. (Spenner 1981) and occupation level scores from Q.E.S. surveys. Sample weighted by occupational size (2671 total)].

JOB DIMENSION SCALE	D.O.T. SCALE	CORRELATION
1. Decision Latitude	. Occup. Self-dir.[1]	.765
	. Data - Complexity	.751
	. People - Complexity	.511
	. Gen. Educ. Devel.	.756
	. Specific. Voc. Prep.	.693
	. Routinization[2]	-.533
	. Close. of Superv.[2]	-.712
a. Skill Discretion	. Occup. Self-dir[1]	.751
	. Data - Complexity	.769
	. People - Complexity	.476
	. Gen. Educ. Devel.	.792
	. Specific. Voc. Prep.	.759
	. Routinization[2]	-.544
b. Decision Authority	. Occup. Self-dir.[1]	.695
	. Close of Superv.[2]	-.652
2. Psych. Work Load	. "Perform. Under Stress"[3]	.060[4](n.s.)
3. Physical Exertion	. Physical Exertion[3]	.624
4. Noise Exposure	. Noise[3]	.485
5. Temperature Extremes	. Hot / Cold[3]	.103[4](n.s.)
6. Hazard Exposure	. Hazards/Toxic Expos.[3]	.596

Explanation of Scale Sources:

All correlations are significant at the .001 level except as noted.

1. This is Kohn's Occupational self direction scale as approximated by Temme (1975), [See Spenner 1981 p.244].

2. These two scales are each constructed by Spenner from two worker trait indicators [see Spenner, 1981].

3. Scores are based on a single worker trait indicator from the DOT or our equally weighted sum of two such measures.

4. Correlation is based on very skewed dichotomous variables, which tends to reduce the correlation. The percentages for the 1-category of the DOT scale are: Perform. Stress 2%, Heat 1%, Cold 5%.

Table 3: CORRELATION MATRIX: JOB DIMENSIONS AND DEMOGRAPHIC VARIABLES

MATRIX 1: QWL DATA 1969, 1972, 1977 INDIVIDUAL LEVEL (n=2845)

MATRIX 2: QWL DATA 1969, 1972, 1977 OCCUPATIONAL AGGREGATE (1970 Census Codes, n=210)

	DISC12	DISC1	DISC2	DEM13	PHYSDEM(—)	JOBSC2	SUPPOR	PHYS1	PHYS4	AGE	EDUC	INCOME
ISC1	.844 .945											
ISC 2	.881 .937	.491 .773										
EM13	.079 .304	.151 .335	-.003 .244									
HYSDEM	.155 .400	.129 .393	.139 .360	-.279 -.079								
BSC2	-.156 -.276	-.121 -.236	-.143 -.281	.157 -.040	-.149 -.374							
UPPOR	.293 .474	.233 .421	.268 .472	-.270 -.027	.072 .112	-.227 -.175						
HYS1	-.114 -.378	-.092 -.343	-.110 -.376	.138 -.120	-.218 -.508	.078 .069	-.173 -.231					
HYS4	-.101 -.270	-.067 -.227	-.109 -.288	.169 -.066	-.286 -.601	.092 .136	-.171 -.209	.628 .829				
GE iv.)	.093 .103	.047 .071	.110 .126	-.154 .003	.018 .026	-.108 -.056	.060 .074	-.041 -.045	-.046 -.038			
DUC iv.)	.331 .452	.358 .473	.222 .378	.146 .202	.306 .439	-.078 -.232	.028 .151	-.129 -.345	-.155 -.342	-.206 --		
NCOME iv)	.242 .262	.240 .252	.187 .244	.128 .159	.157 .183	-.051 .104	.054 .113	-.066 -.144	-.069 -.145	.104 --	.266 --	
UNCAN	.442 .690	.460 .722	.320 .576	.113 .293	.402 .701	-.156 -.378	.095 .265	-.202 -.500	-.244 -.504	.055 .047	.591 .595	.299 .281

(Taylor 1947 and Braverman 1974). These two concepts arise from different aspects of work organization strategy, but are theoretically linked (expertese legitimates authority in Weber's bureaucracy [1947]) and empirically linked (highly correlated), and are therefore often combined for analytic purposes. Our two measures, "skill discretion" and "decision authority", reflect this distinction - which is also found in the job design and stratification literatures: for example, Gardell's "freedom" and "qualification level" scales (1971); and the two central components of the Hackman and Oldham (1976) Motivating Potential Score (autonomy in task organization decisions and variety in skill usage); Spaeth's (1979) "authority" and "complexity"; two of Kohn and Schooler's (1973) subcomponents of "occupational self direction": closeness of supervision and substantive complexity; and the DOT worker trait scores for "closeness of supervision" and "routinization" organized by Temme (1975) and Spenner (1980).

In analyses with large samples, "decision authority" and "intellectual discretion" are correlated (r=.49 in our U.S. data; see also high correlations between similar measuress in Hackman and Lawler [1971] and Jenkins et al [1975]). Thus, highly skilled work that allows little decision authority appears to be a relatively rare occurrence (although Frankenhaeuser and Gardell [1976] describe such a job for lumber graders).[17] Therefore, in analyzing the U.S. data, we additively combined measures of decision authority and measures of intellectual discretion into an aggregate scale (consistent with most literature cited above). In future research it would be desirable to distinguish between the effects of several different aspects of decision latitude (i.e., with respect to skill, task organization, time pacing, control over uncertainties, decision resources, and organizational policy influence). However, our combined decision latitude scale appears to closely approximate a "core" of generally inter-correlated measures of "control at the workplace."

I.A Skill Discretion: keep learning new things; requires high skill; requires creativity; repetitious (-) [i.e., negatively scored]

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[17] We observe a similar pattern for typographers, and the opposite pattern of low skill with high authority for gardeners and garbage collectors.

I.B Decision Authority: have freedom to make decisions; can choose how to work

I.C Decision Latitude (Skill Discretion + Decision Authority)

The decision latitude dimensions are constructed from seven questions identical across survey years. These measures are statistically the strongest occupation-based dimensions among our set with cross survey reliability of 0.95 for decision latitude, 1.00 for skill discretion, and 0.94 for decision authority. They have scale reliabilities of 0.67, 0.67, and 0.54, respectively. These measures also clearly differentiate between occupations, with the between occupation variance accounting for 48% of the reliable variance in decision latitude and 51% and 36% for skill discretion and decision authority, respectively.

Validation of the decision latitude scales comes from correlations with worker trait data on the DOT obtained from the Spenner 1981 tape. As shown in Table 2, the DOT estimates of Kohn's "occupational self-direction" scale is correlated 0.77 with decision latitude; the DOT scores for "closeness of supervision" and our decision authority scale are correlated 0.65, while the DOT "routinization" scale, and general and specific training time (GED),(SVP) scale[18] are correlated with our skill discretion scale -0.54, 0.79, and 0.76, respectively. Also noteworthy are the correlations between the DOT worker function level for data and people, and our skill discretion (r = 0.77, and 0.48 respectively). Content validity of our dimensions is also attested to by the high correlation between "objective" and self report measures of decision

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[18]The significant correlation (r=.33) between education and decision latitude (paticularly the skill discretion component; r=.36) have raised the question of whether these job scales simply measure educational attainment. However, the discrepency between education and required job skill is known in other literature as "skill underutilization" and is the focus of substantial research in its own right as a contributor to work morale, low productivity (Karasek, 1979b) and "overproduction" in education (Freeman 1976). The QES surveys show that 26% and 36% of the U.S. workforce in 1969 and 1977 respectively indicated a discrepency between job skill requirements and actual education (Quinn and Staines, 1979).

latitude. A Swedish self-reported skill discretion measure correlates highly with expert ratings [Carlsson, et al, 1974] (r=.69 in 1968; r=.64 in 1974), corroborating other findings (r=.78 Kohn and Schooler 1973; r=.87 [average for autonomy and variety] Hackman and Lawler 1971; and Gardell 1971).

2. Psychological Work Load

This measure is designed to tap the overall demands, or psychological "costs" ("arousal" Welford, 1976; Bainbridge, 1974), necessary to carry out the task (i.e., work load, time pressure, deadline stress, etc.). Physical exertion is not included, and thus the measure is not intended as a global indicator of taxing work demands. It is difficult to empirically assess the exact source of even the psychological demands given the nature of our data (conflicts on the job could also increase this burden, for example), although Buck (1972) notes that the task requirements are the most common source of such loads. Theoretical and research problems involved in measuring even the "mental work load" are considerable, and no consensus has yet emerged as to the most desirable techniques, even in laboratory contexts. However, support does exist for the use of subjective reports of work load based on scales when appropriate reliability assessments are included (see reviews by Williges and Weirwille 1979 and Bainbridge 1974).

Broad questions about work load ("not enough time") are probably more likely than specific questions to be affected by individual "biasing" factors (Lazarus, 1966; Bjorkman and Lundquist, 1978). We consider this to be a substantial shortcoming of our dimension, and this may account for the relatively low between-occupation variance of this dimension. However, there is evidence to suggest significant objective content to our measure in spite of these weaknesses. Similar measures have low correlations with reports of stressors in other spheres of life (Karasek, 1976), thus there is little evidence of a "halo effect" where strain in other spheres of life is reported as strain due to job causes. Also self reports correspond well with expert assessments in several studies (Gardell 1971, Ager et al 1975). Finally, our occupation scoring method identifies (see Figure 5) occupations that are plausibly high and low on psychological work load (e.g., high: orderlies, lawyers, waiters, typesetters, physicians; low: rail conductors, bookbinders, jewelers; see Appendix VII).

II.A Psychological Work Load:
No excessive work (-); No conflicting demands (-); Have time (-); Work fast; Work hard

II.B Hours of Work

II.C Customer Hostility:[19]
Exposed to attack or hostility by persons or animals

The psychological work load dimension is an additive scale constructed from five questions identical in all survey years with acceptable scale reliability within surveys (Cronbach's alpha = 0.61) and good cross-survey reliability (0.86). Unfortunately the dimension discriminates poorly between occupations: (eta^2 as a percentage of the reliable variance is only 11%). Hours of work per week, based on a single question response, has a substantially higher between occupation variance (eta^2 = 21%). However, time spent on the job cannot be considered a very precise measure of the psychological "costs" of work activity.[20]

3. Job Insecurity

This dimension is designed to estimate the threat or reality of job termination or layoff faced by the employee. A related issue, but not well measured by our dimension, is the possibility of career path obstacles: "dead end jobs" or technical redundancy. Empirical measures of job insecurity in large scale analyses typically tabulate rates of actual unemployment

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[19]This third stressor available in our data base is a type of personal hostility, but we limit its usage because of the narrowness of the measure). It appears, primarily, to capture hostility directed toward workers by customers, an important stressor for several groups of white collar workers. Other analyses show that it fails to capture the generalized hostility or conflict among workers or between workers and managers, that has been described in blue collar jobs.

[20]Only a single rather narrowly defined question on the DOT is available for cross-validaton with our scale and that correlation is poor (r= 0.06); but the frequency of that dichotonous variable, 2% dramatically limits the correlation magnitude.

experienced by analytic category (although not occupation, see Brenner, 1971 and Catalano and Dooley, 1977). Given the rate of unemployment, this strategy requires a very large data base, when using several hundred occupations (representing as little as .1% of the workforce in our strategy). Furthermore, the experience of unemployment may differ from the threat of unemployment. The threat may be the more potent psychological stressor (Langner and Michaels, 1963) since it is the signal that triggers the individual's costly efforts to readapt his/her life circumstance. Measures of the threat of unemployment could be subject to greater error due to self-reporting biases.

III. A Job Insecurity:
How steady job is (-); Good job security (-)

The job insecurity dimension is an additive scale composed of two questions that are identical across survey years. The cross-survey reliability is a respectable 0.84, however its scale reliability is weak (Cronbach's alpha = 0.29). This suggests that we are averaging two fairly different aspects of job insecurity (if each is fairly reliable, their average will also be reliable although Cronbach's alpha will be low). However, the dimension distinguishes between occupations remarkably well (eta^2 between occupations = 37% of the reliable variance). In the future we intend to correlate our scores with national data on unemployment by occupation in order to compare actual and perceived threat/risk. It would be best to have unemployment rates broken down by detailed occupational code, age, education, race and sex since these factors obviously affect unemployment levels. The content validity of our job insecurity scale is qualitatively attested to by the plausible placement of occupations scoring high and low on the measure (high: artists, construction laborers and other building trades; low: railroad engineers, mail carriers, telephone linemen, bookkeepers; see Appendix VII).

4. Social Support

The "social support" dimension is designed to measure overall levels of "helpful" social interaction available on the job from both coworkers and supervisors. There are diverse mechanisms by which social relations at work

may affect our health measures, but we have concentrated on three that are measurable by questions in the QES. First, social support could measure "buffering" mechanisms between psychological stressors at work and adverse health outcomes (LaRocco, House and French 1980, Karasek, Triantis and Chaudhry 1982). Second, social support could measure the degree of interdependency between workers which could affect the ease of obtaining assistance in task performance or the difficulty of coordination problems (Turner 1980). Third, social support could measure the strength of social integration in the work group (Homans 1950). The "stress buffering" mechanism has recently been elaborated in a rich literature, empirically based on data similar to the QES. In addition to separating coworkers and supervisors as sources of social support (LaRocco, House and French 1980, French, Rodgers and Cobb 1974), this literature observes a potential dichotomy between "instrumental" and "emotional" support, particularly from supervisors (similar to Bales and Slater's role dichotomy 1954).

IV.A Supervisor Support:
Encourages new ways; Concerned with employees; Talks before decisions; Pays attention; Allows autonomy

IV.B Coworker Support:
Chance to make friends; Helpful coworkers; Coworkers take personal interest; Friendly coworkers

IV.C (Supervisor Support + Coworker Support)

The construction of the social support dimension is more complex than other dimensions because the available questions in the QES differ across years (see Appendix IV). Our method is to select questions as similar as possible on face validity and factor loadings (1972 and 1977 questions are almost identical), and to construct a standardized indicator in each survey. The overall scores for occupation are then weighted averages of the three standard scores. Factor analysis has also revealed the difficulty of defining consistent factors across the three samples for instrumental and socio-emotional support. (The combined instrumental/socio-emotional unrotated first factor accounts for about 70% of the common variance.) Somewhat separable factors of this type are found in 1972 data alone, especially for coworkers (Karasek, Triantis and Chaudhry 1982). However, in all cases, separate

coworker and supervisor support factors emerge, combining instrumental and socio-emotional support characteristics.

The scale reliabilities of the coworker, supervisor and combined coworker/supervisor measures are quite high, with Cronbach's alpha = 0.72, 0.82, and 0.84 respectively, and their cross-survey reliabilities are also very high (1.00, 1.00, and 1.00). However, we find very little systematic difference between occupations for either coworker or supervisor support or the combined indicator (eta^2 = 2.9%, 3.4%, and 4.8%, respectively). Since very similar scales from the QES data, when used at the individual level, display "social support buffering" effects quite similar to those found in other data bases (Karasek, Triantis and Chaudhry 1982), we have little reason to suspect that the problem lies in the content validity of the scales. This lack of between-occupation variance could substantially restrict the utility of the measures in a job characteristic inference system.[21]

5. Physical Exertion

The goal of this dimension is to measure the level of physical exertion required on the job. In addition to the overall level of exertion, other aspects, such as the regularity of exertion, the level of impulse loading (Fox and Haskell 1968), as well as static loads imposed by spending long time periods in uncomfortable positions (Fredriksson and Voight 1979, Tichauer 1973), could be important aspects of physical work load that affect health and behavior. Our measure suffers from the common problem of exertion indicators in large population studies (Milvy, Forbes and Brown 1977): lack of specific information on the above subcomponents of exertion. Our dimension is constructed from a single question on overall exertion. We would interpret its content as roughly measuring the taxing results of exertion level and impulse loading combined, but conveying little information about static loads (e.g. uncomfortable positions) or exertion regularity.

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[21]However, it should be noted that in spite of this low between-occupation variance the estimates of association between a QES depression scale and occupation based social support scores closely duplicate findings obtained from the individual level data on which these scores were based (see Schwartz, Karasek and Pieper, 1982).

V.A Physical Exertion:
Job requires regular physical exertion

The physical exertion dimension is constructed from only one question (a four-level scale) available in two survey years, so no scale reliability analysis can be performed. However, the cross-year occupation level reliability is very high (alpha = 1.00). Furthermore, this dimension is rather well differentiated by occupation with an eta^2 of 26%. In addition, the indicator identifies plausible high exertion occupations: lumberman, orderlies, mill workers and the zero level of the scale includes a very large number of white collar and professional occupations (see Appendix VII). We are able to correlate these scores at the occupation level with worker trait information available on the DOT using the Spenner tape (r= 0.62) in Table 2, a very repectable validation given the limitations of the scales in both data bases.

6. Physical Hazards Exposure

Noise has been identified as a causative agent in the development of psychological stress (Glass and Singer , 1972) and in the possible development of cardiovascular illness (Hattis, Richardson and Ashford, 1979; Jonsson and Hansson, 1977). However our self report noise measure falls far short of physical monitoring in accuracy, although useful discussion of the population incidence of noise exposure has been made with such scales (Sundbom, 1971). The hazard indicator must be judged as a generalized risk indicator of exposure to hazardous conditions and toxic exposure, and is far too imprecise to identify specific etiological agents which might lead to illness. Its utility as a general hazard indicator however, is confirmed by its respectable correlation (0.60) with occupational hazard measures on the U.S. Dictionary of Occupational Titles using the Spenner tape in Table 2.[22]

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[22]The temperature extremes scale correlation wth the DOT is a poor (r = 0.10), however the very low frequencies of the DOT dichotomous cold and hot questions (1%, 5%) would dramatically limit the correlation.

VI.A Noise:
Exposure to excessive noise

VI.B Temperature Extremes:
Exposure to extremes of temperature and humidity

VI.C Toxic Agents/Hazards:
Job involves exposure to air pollutants; fire; toxic chemicals; dangerous equipment or methods; poor maintenance

C. COMPARISON OF THE JOB CHARACTERISTICS SCORES WITH SOCIO-ECONOMIC STATUS

We can gain some understanding of the utility of this new system of job characteristics by comparing the system to conventional occupational status measures using regression analysis. In Table 4 we attempt to predict the job characteristics scores using income from employment, education, and the Duncan S.E.I., based on data from the Quality of Employment Surveys. In Table 5 we attempt to predict the Duncan S.E.I. with the job characteristics; and compare the success of the prediction to that obtained from income and education. While predicting the Duncan scale is no ultimate criterion of validity[23], given our concern with health outcomes of work, it would be of merit for our system to illustrate that it can also capture the variance of conventional prestige systems.[24] In both analyses, the regressions are performed with both individual and occupational aggregate level data. The occupation level analysis to predict Duncan score from job characteristics should be quite comparable to Duncan's original methodology in constructing the S.E.I. through

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[23]Featherman and Hauser, (1976) consider the scale to be a more "valid" indicator of occupational socio-economic status than even direct prestige measures.

[24]Income from own employment is gathered in the U.S. Quality of Employment Survey on a nine gradation scale (level 1 </= $2,000; level 9 >/= $35,000; see Appendix IV). We use category midpoints to estimate exact income. "Own employment" income covers direct wages, salary, and tips and bonuses, but excludes benefits such as insurance and meal reimbursements.

Table 4

Predicting Job Characteristics with Social Economic Indicators/Quality of Employment Surveys 1969, 1972, 1977 (n=2298 Indiv. level /2730 Occupation level)

(r^2) INDIVIDUAL LEVEL ANALYSIS

	Full Populat.			Lower/Working (Lower 67%)			Upper Middle* Top 33%		
	Duncan	Inc/ed	Dunc/Inc/ed	Dunc.	Inc ed	Dunc Inc/ed	Dunc.	Inc/ed	Dunc/Inc/ed
Decision Latitude	.193	.158	.225	.085	.063	.116	.021	.101	.102
- Skill Discretion	.217	.181	.251	.101	.080	.140	.030	.112	.113
-Decision Authority	.089	.071	.106	.035	.024	.047	.006	.045	.044
Psyc. Work Load	.012	.038	.087	.000	.019	.023	.000	.024	.025
Job Insecurity	.017	.010	.023	.019	.010	.026	.000	.002	.002
Social Support (coworker & Superv.)	.008	.003	.010	.002	.000	.003	.000	.004	.003
Physical Exertion	.159	.086	.161	.072	.011	.075	.056	.059	.078
Noise Exposure	.042	.013	.042	.006	.001	.010	.006	.009	.010
Physical Hazards	.028	.003	.032	.001	.015	.022	.005	.012	.012
Job Strain (Psyc,Dem-Decis.Lat.)	.058	.021	.060	.052	.038	.009	.010	.010	.013

(r^2) OCCUPATION LEVEL ANALYSIS

	Dunc.	Inc. ed	Dunc. Inc/ed	Dunc.	Inc/ ed	Dunc/ Inc/ed	Dunc	Inc/ ed	Dunc/ Inc/ed
Decision Latitude	.470	.461	.510	.191	.269	.319	.151	.274	.274
-Skill Discretion	.512	.493	.568	.243	.291	.358	.252	.352	.363
-Decision Authority	330	.336	.368	.100	.122	.191	.030	.127	.139
Psyc. Work Load	.089	.109	.108	.012	.023	.059	.001	.003	.005
Job Insecurity	.141	.110	.141	.169	.191	.215	.000	020	.021
Social Support (Coworker & Super.)	.024	.171	.182	097	.117	.221	.065	.249	.256
Physical Exertion	.496	408	.513	.312	.303	.403	.252	.158	.255
Noise Exposure	240	.237	.257	.022	.031	.041	065	.220	.232
Physical Hazards	.253	.246	.272	.020	.092	.097	.058	.176	.182
Job Strain (Psyc,Dem-Decis.Lat.	.107	.092	.109	.56	.079	.170	091	.127	.130

Table 5

Predicting Occupational Status (Duncan S.E.I.) with Job Characteristics/compared to Income,education/ Quality of employment Surveys 1969,1972,1977 (n=1681 -'69,'72 Individual level/2730 Occupational level)

(r^2)

	Decis. Psyc.d	Decis. Psyc.d Phys.d	All Job Charac	Ed.	Inc ed	Decis Psyc.d Inc/ed	Decis Psyc.d Phys.d Inc/ed	All Job Charac Inc/ed
Duncan S.E.I. Full Populat.	.209	.353	.376	.370	.608	.452	.505	.517
Duncan S.E.I. Lower/work (66%)	.080	.164	.177	.142	.142	.182	.239	.249
Duncan S.E.I. Upper/midd*(34%)	.026	.074	.078	.215	.215	.213	.228	.226

(r^2)

	Decis. Psyc.d	Decis. Psyc.d Phys.d	All Job Charac	ed	Inc/ed	Decis.Psyc.d Inc/ed	Decis.Psyc.d Phys.d Inc/ed	All Job Charac Inc/ed
Duncan S.E.I. Full Populat.	.481	.727	.741	.728	.740	.764	.818	.822
Duncan S.E.I. Lower/work (68%)	.214	.402	.563	.477	.478	.535	.598	.606
Duncan S.E.I. Upper Midl * (36%)	.168	.339	.321	.506	.523	.525	.578	.591

* Upper middle class defined as Duncan Score >50

occupationally-aggregated income and education data.[25]

The regression analyses in both Tables 4 and 5 are performed not only on the full male population, but also on two separate subpopulations: an upper-middle class group (defined as Duncan scores over 50) representing 33% of the population, and the remaining 67% of the population - the broad lower middle and working class. The rationale behind the subpopulation analysis is based on a hypothesis regarding the collinearity of job characteristics and status scores. We suspect that job characteristics which are commonly thought to be related to status in the occupational hierarchy (decision latitude, physical exertion, job insecurity, noise and hazard exposures) may be correlated with S.E.S. measures in high status groups only (Karasek, 1976 p. 272). On the other hand, for the broad mass of the population we hypothesize that these job characteristics may be relatively independent of S.E.S. measures. This phenomenon may be true either because the conventional status scales only predict extremes of job circumstance, or because the "constellation" of job characteristics, that relate to status differs by class. Furthermore, we would suggest that the combination of job characteristics which correlate with "status", may not be the same combination which predicts, for example, health outcomes. The implication of any of these mechanisms would be that analyses of the effects of occupation based on conventional social status scales alone could very well overlook the major associations of job characteristics with health.

The results of the occupational level analysis in Table 4 show first that the S.E.S. indicators are not very good predictors of most job characteristics in the full population - particularly for job characteristics at the individual level. Table 4 shows that the R^2's for the Duncan scale are 19% and 16% respectively for the most "status-related" measures, decision latitude and physical exertion. For no other dimension does R^2 reach 5%, and adding income and education as predictors yields little improvement. At the

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[25]Our methodology uses the mean income and education score for each occupation, whereas Duncan's method was based on the percentage of each occupation over a specified income or education criterion level.

occupational level the prediction is much better for some job characteristics, since within-occupation variation disappears, but the majority of job characteristics are not strongly predicted by status measures.[26] Although the Duncan S.E.I. does account for 47% of the variance for decision latitude, and 50% of the variance for physical exertion, no other job characteristic has more than 25% of its variance explained by either Duncan SEI, income or education. More remarkable is the lack of explanatory power for status when the population is split into broad lower and upper middle class subgroups. While substantial loss of variance in the Duncan score as an independent variable can be expected when the subpopulation is dichotomized by Duncan score, the loss of explanatory power seems much greater than would be predicted by that factor alone, given, for example, the still large lower middle and working class group (67% of the population). The explanatory power of the Duncan scale for decision latitude declines from 47% to 19% in the working/middle class group and the physical exertion R^2 drops from 50% to 31%. This "within-stratum" drop in predictive power of the Duncan scale occurs most clearly for job stressors: for psychological work load, noise exposure, and physical hazard exposure respectively, R^2 drops from 0.09, 0.24, and 0.25, in the full population to 0.01, 0.02, and 0.02 in the working/middle class group. For these measures, a possible "class-related" discontinuity may "account" for major differences in job exposure. However, occupational status scales within the broad working/middle class accounts for little additional variance.

Table 5 reveals the significant ability of the job characteristics to predict the Duncan scale, the most widely used measure of occupational status. Using occupational aggregate data we see that in the full population the job characteristics scores predict as much of Duncan S.E.I., (R^2 = 0.74) as do occupation level education and income - from which many Duncan scores are directly derived. More interesting, just three job characteristics: decision latitude, psychological work load, and physical exertion predict 73% of the Duncan scale variance (with standardized beta coefficients of 0.41, 0.20 and -

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[26] It is interesting to note that income and education add very little to the predictive power of the Duncan scale at the individual level or the occupation level (except when the analysis is performed separately for status subgroups).

0.55, respectively).[27] The associations of this type have been attributed to the "functionality" of occupational status scores by Treiman, 1977, and confirmed by Cullen and Novick, 1979 (although it would be hard to prove that physical exertion should be "dysfunctional" to effectve job performance). In summary, our job characteristics measures appear to capture most of tne variance in the conventional occupational status indicator, but the reverse is not true. Most job characteristics can not be well predicted by status alone, particularly within the working/middle class. This implies that analyses with our specific job characteristics measures are likely to lose little over conventional status analyses, but promise to capture more variance in true job experience than conventional status measures. Futhermore, the specificity of the job measures implies that they may more successfully measure detailed pathways of "production" of health and health arising out of work organization.

Is it true that our job dimensions predict health outcomes better than a unidimensional status scale? Thorough analysis of this possibility is beyond the scope of this paper, but data on psychological strain available in the same Quality of Employment Surveys allows a preliminary test. We use a composite measure of psychological strain[28] for the analysis, and perform the regressions at the aggregate occupational level. This reduces the possibility of personal response bias linking job characteristics and psychological strain, and duplicates the methodology of the Duncan score comparison above. Using physical exertion, decision latitude and psychological work load, we predict occupational level psychological strain with an R^2 of 0.33. Using the Duncan scale alone the R^2 is only 0.067, one fifth as great. Recall, we could

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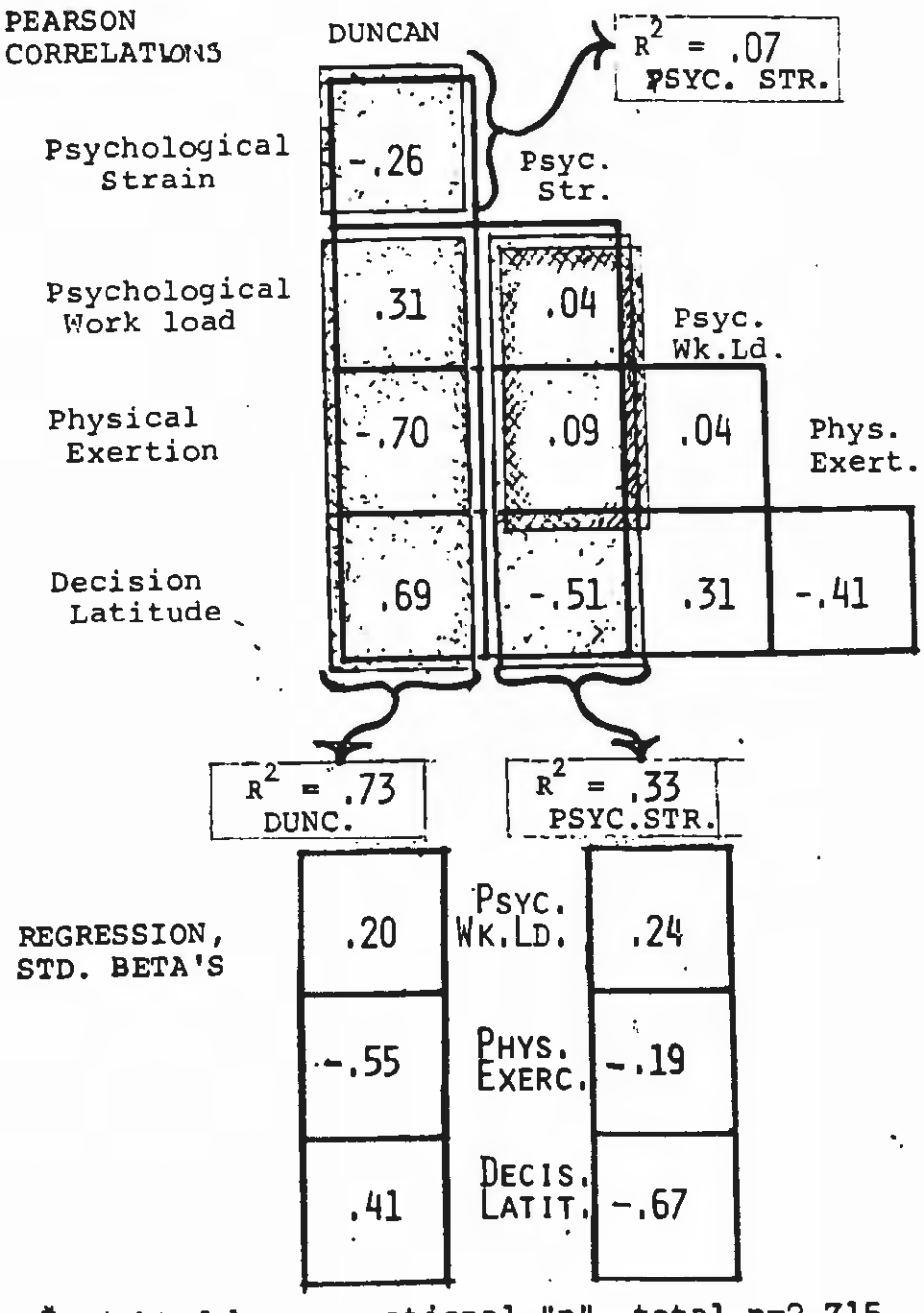
[27]Kohn and Schooler (1982) make the case that a single dimension of job experience, substantiative complexity of work (like our skill discretion or perhaps the decision latitude composite), is the central determinant of many causal relationships involving workplace behavior. They also find that this dimension of work explains 81% of the variance in status scales -- somewhat more than our three dimensions combined.

[28]This is a sum of z-scores for depression (U. Michigan's affective life satisfaction), job satisfaction (U. Michigan's facet-free job satisfaction), physical signs of psychosomatic stress, and sleeping problems.

TABLE 6 ASSOCIATIONS BETWEEN JOB CHARACTERISTICS, DUNCAN S.E.I., AND PSYCHOLOGICAL STRAIN (COMPOSITE)

Occupation Level Analysis 1970 Census Occ. Codes (n=210)*

Quality of Employment Surveys, 1969, 1972, 1977



*Weighted by occupational "n", total n=2,715

predict most of the variance in the Duncan scale (R^2 = 0.73) with the same three job dimensions. It is interesting to compare (Table 6) the standardized beta coefficients for predicting Duncan S.E.I. to the betas for predicting psychological strain: 0.41 vs.. -0.67, respectively for decision latitude; 0.20 vs. 0.24 for psychological work load; and -.0.55 vs. -0.19 for physical exertion. The combination of job characteristics that predicts psychological strain is simply different from the combination that predicts socio-economic status. Particularly dramatic is the switch in the case of decision latitude from a positive to a negative beta. This has several implications: the low control available in low status jobs appears to be a more important contributor to psychological strain than the conventionally identified correlate of white/blue collar status: physical vs. mental exertion. (Indeed, some types of physical exertion common in many blue collar jobs appear to be protective, cancelling out the stronger effects of low control for low status jobs.) Secondly, if occupational status scores (such as Duncan S.E.I.) were used to predict stress-related illness, the protective impact of these kinds of physical exertion would partially suppress the aggravating effects of low control. This could result in the marginal social status association (R^2 = 0.067) which we and others observe (Dohrenwend and Dohrenwend 1974) when simple unidimensional status scales are used to summarize the impact of occupation on psychological stress. It is interesting to note that a very similar pattern of job/illness associations appears when coronary heart disease replaces psychological strain as the dependent variable (Karasek, Theorell and Schwartz, 1982b, Alfredsson et al 1982, and Karasek et al 1981, and discussion by Schwartz, Karasek and Pieper 1982, p.__). Thus, we suspect that the conventional wisdom of weak linkages between "occupation" and stress-related illness is due to the methodological failure of conventional status measures; other models and measures can reveal markedly stronger associations.

The groups at highest risk for occupationally related psychological strain are not the groups at the low end of the Duncan scale but workers with low decision latitude, low physical exertion and high psychological work load. Because low decision latitude and high physical exertion are substantially correlated (r = 0.41, these occupations are easily overlooked in analyses with unidimensional scales. Such occupations are clearly "low status" in many

important respects, but their positions on conventional status scales is ambiguous. In general, the conventional status measures appear to be too unidimensional in their conceptualization of occupational experience to accurately delinenate mechanisms of illness causation. Our job dimensions are much more precise in their description of a worker's relationship to the means of production and are therefore better able to measure the pathways of causation that are theoretically relevant for the production of illness (Ferrarotti, 1980). Perhaps the "precision" of these (still very rough) job dimensions would provide similar advantages over the status scales in predicting other aspects of work related health. These conclusions suggest that methodologies of occupational analysis must be reconsidered for this type of research and measure of job content must, at the very least, supplement S.E.S. measures. Alternatively, a new metric of status should be created from job characteristics that more closely reflect the non-economic costs of the work process on the worker. To gain a crude understanding of what the concept of "status" or "stratification" might imply in such a multidimensional job characteristics context, we next turn our focus to the distribution of occupations along our job dimensions.

D. DISTRIBUTION OF OCCUPATIONS IN JOB CHARACTERISTIC SPACE

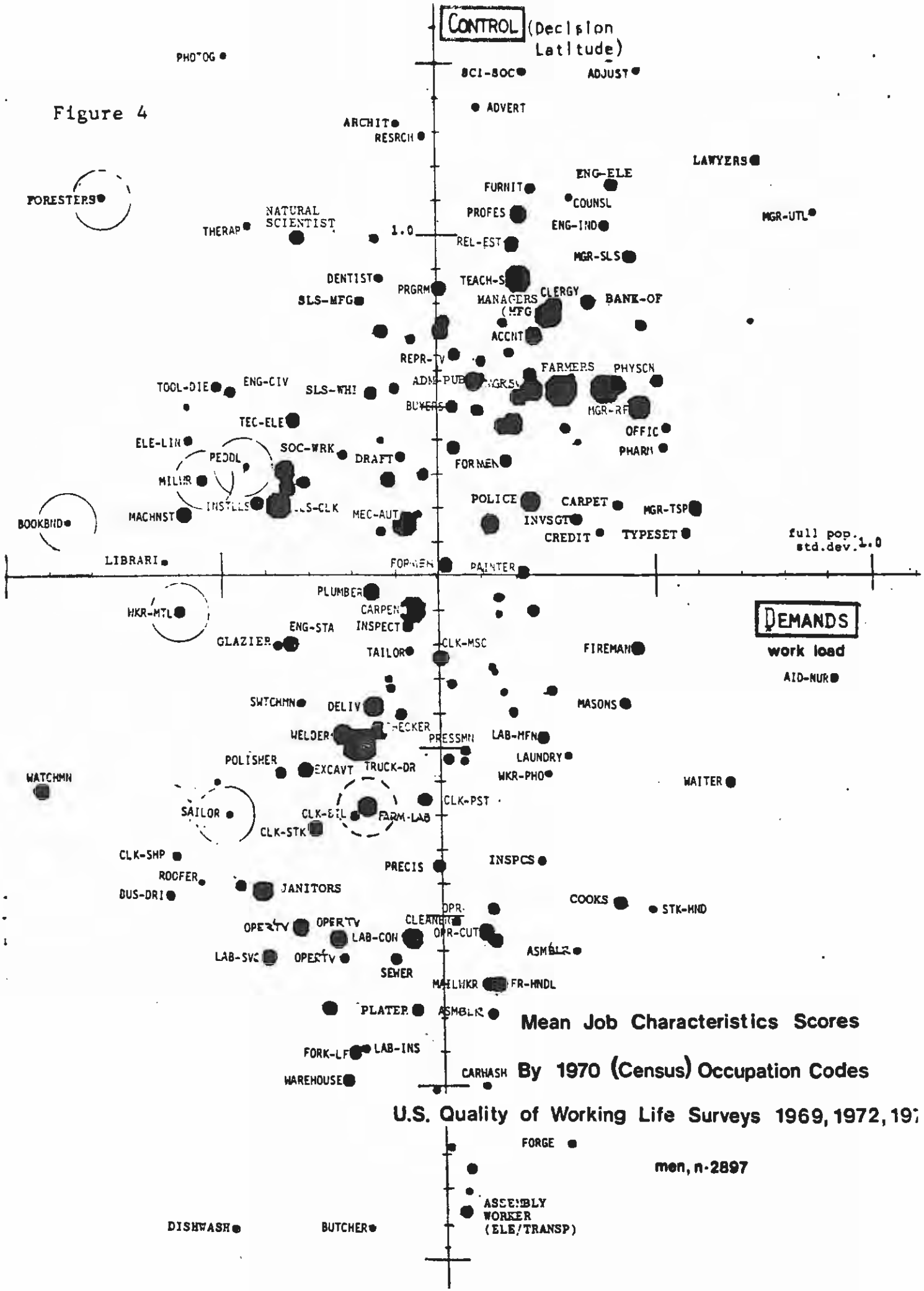
How can we understand the information about the occupational system contained in a system of job dimensions? We could examine the distribution in a multi-dimensional space of job characteristics, and observe which occupations appear in different parts of the distribution. In Figures 4 and 5 we select two dimensions from our set of fourteen (to construct a two-dimensional plot of occupations). Decision latitude and psychological workload demonstrate significant associations with psychological strain and physical illness behavior patterns in work and leisure (see Appendix II). These dimensions are plotted on a relative scale: with one unit equalling one standard deviation at the individual level of the full male population, while the origin of the plot corresponds to the individual level population means. (Thus, the fact that the distribution of occupations in Figure 4 is "longer" along the decision latitude axis indicates that there is more between-occupation variance along that dimension than along the psychological workload axis.) The relative positions of occupations with known job content can also

be compared in Figure 4 to provide a rough test of construct validity for the job dimensions. Using this diagram we observe, for example, that managers and assembly line workers in the auto and electrical equipment industry differ in decision latitude by more than 2.6 standard deviations. This confirms ($p </= 0.001$) the conventional widsom, that auto workers have, "objectively", less decision latitude in their jobs than auto factory managers. These conclusions about "stratification" differences between occupations have the advantage of being defined by direct individual reports of job experience.

1. Quadrants of Psychological Job Quality - Male Sample (Figure 4)

What "structural characteristics" of the occupational distribution are observable using this graphical/analytic tool? We find major differences in the psychosocial character of occupational experiences in each quadrant of Figure 4. The upper right hand quadrant, where psychological demands and decision latitude are both high, clearly seems to be the locus of high prestige occupations (the "active" jobs): lawyers and judges, physicians, professors, engineers, managers, etc. Burning the candle at both ends with an active work and leisure (and maintaining average health to boot), this group receives higher incomes, but even more dramatically, enjoys the highest psychic rewards from work (Karasek, 1976). However, low and middle status occupations may be found rather uniformly dispersed among the other three quadrants. In the high decision latitude/low demands quadrant (i.e., "leisurely work"), we find self-paced occupations such as repairmen, sales clerks, and natural scientists. In the low demand/low decision latitude quadrant (the "passive" jobs), we find transport operatives and some non-public contract service personnel (janitors). While these "passive" jobs take only a modest toll in terms of poor health, they are associated in Swedish and U.S. data with a social and political isolation that could be dangerous to a democratic society (Karasek 1978b, Goiten and Seashore 1980, respectively). We can also examine the "high strain" quadrant group that corresponds to our regression predictions of high psychological strain from the previous section: low decision latitude and high psychological work load. We find machine-paced operatives (assemblers, freight handlers), as well as "service operatives" (waiters, cooks). (Psychological strain scores of each occupation, along with physical exertion scores, are presented in Table 9 and Figure 11 (also Schwartz, Karasek and Pieper, 1982).

Figure 4



Mean Job Characteristics Scores

By 1970 (Census) Occupation Codes

U.S. Quality of Working Life Surveys 1969, 1972, 197

men, n-2897

We also observe that a new set of broad occupational aggregations related to major types of production structures in U.S. society, may be defined with the help of Figure 4. The most thoroughly analyzed organizational form in our society is probably the Weberian bureaucracy based on private capital, producing a physically tangible output. An ideal-typical example is a large manufacturing organization with a classical hierarchical structure such as the steel company described by Perrow (1972). We can identify five "major" occupational groups that might belong to such organizations - in order of descending decision latitude: first, managers and professionals performing staff functions at the high status level (engineers, lawyers, accountants); second, administrators and technicians; third, clerical and secretarial personnel. Finally, blue collar "labor" appears to 'bifurcate' into two categories: machine-paced operatives, non-paced workers, and laborers - vs. - transport-based and delivery personnel, (at somewhat higher decision latitude and lower demands). While these five categories of the Weberian bureaucracy span the full range of decision latitude, job demands fall consistently in the middle range (a bit higher for managers). The extremes on the job demand scale appear in <u>other sectors</u> of the economy. For example, we can observe differing occupation experiences in the "service sector" - which often involves intangible human welfare and public ownership: major public service bureaucracies exist with "service professionals" (nurse, policeman, fireman). While these occupations are "point-of-production" (and thus "line workers"), they have an autonomy granted by professional standards, and moderate freedom from strict supervision. However their job demands are relatively high (as they also are for other medium-status quasi-independent professions such as typographers and pharmacists). Another category of service workers with relatively high decision latitude are on the low demand side of Figure 4: service providers (non-professional) such as sales clerks, and repairmen, who cannot be directly supervised because of the importance of the client contact. Still another group of low status (low decision latitude) service workers at <u>low</u> demand levels are personal service "aides" such as cleaners and household care workers, and organizational ancillary personnel (watchmen, janitors). Traditional crafts do not form a compact cluster on our diagram: they represent a band at midlevel decision latitude, spanning the range of high and low job demands (construction crafts toward the center). Finally, one group of professionals (called "free professionals" in Swedish nomenclature of the

last decades) can be indentified with very high decision latitude and moderately low demands. This group, consisting of natural scientists, some artists, professors, and research workers, may be distinguished by their "long term" as opposed to "short term" work goals. Such goals could diminish daily deadline pressures, yielding low psychological strain for the group (for empirical evidence see Table 3, Schwartz, Karasek, Pieper, 1982).

2. Job Content and Historical Trends in Industrial Development

Our sample, drawn from the U.S. population in 1969 through 1977, hardly provides us with data to directly test hypotheses about historical trends in changing job content.[29] However, examination of the men's occupational distribution in Figure 4 suggests impressionistic "clues" about some long term trends. Several occupations (circled in Figure 4) were more common in pre-industrial times: sailor; blacksmith; peddler; forester; members of the clergy (a cast of characters from Chaucer's Canterbury Tales). They are "leisurely" jobs in our present frame of reference: low in psychological demands with high decision latitude (although the physical demands of their work may have been quite high). However, we find the "newer" jobs of the present industrialized era in the "high strain" quadrant - at the diagonally opposite end of Figure 4. The industrialized "proletariat" is located here: punch press operators, assemblers, garment stichers, office machine operators (among women); and freight and material handlers. These occupations are undeniably newer than the "medieval" group above, and were often "designed" in the context of the rigid task specification and time pacing of Fredrick Taylor's Principles of Scientific Management (1947). Indeed, it should be noted that many of these occupations are lower in decision latitude and higher in demands (i.e. higher in psychological stress) than even the traditional "peasant" occupation of the past: farm laborer (circled in the "passive" quadrant in Figure 4). Of course these rough observations are only conjecture, since the job content of occupations may change over time - but the job content differences are quite

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[29]For limited computations of such changes from 1969 to 1977, see Schwartz, Karasek and Pieper 1982. The analysis is based on the assumption of constant distribution of workers into occupations, and test for changes in job content within occupations, net of occupational shifts.

extreme.

These observations confirm an impressionistic picture of an industrial evolution away from jobs that were of low psychological stress to those of high psychological stress. Such a transformation, in terms of diminishing decision latitude, is consistent with Braverman's hypothesis (1974) and empirical findings by Spenner (1979) and Dubnoff (1978). Although little research has been done to examine possible increases in psychologically demanding work, such a trend is observable in Sweden from 1968 to 1974 (Johansson 1976b). In fact, a replacement of physical exertion by psychological demands was an almost explicit "trade off" of the industrial revolution. Such historical changes may have diminished the incidence of some diseases in society, - but actually increased others (see Sterling and Eyer 1981). Cardiovascular illness (which escalated from a secondary cause of death in the late 19th century to the cause of 44% of male mortality today) may have increased because of such factors. Also, since several types of physical exertion appear to be "protective" for cardiovascular illness, some of these psychological consequences may be further exacerbated by the diminishing physical exertion of jobs. Such, admittedly speculative, changes due to occupational transformation are of a type that would be largely obscured in analyses using conventional S.E.S. measures for the reasons discussed in the previous section.

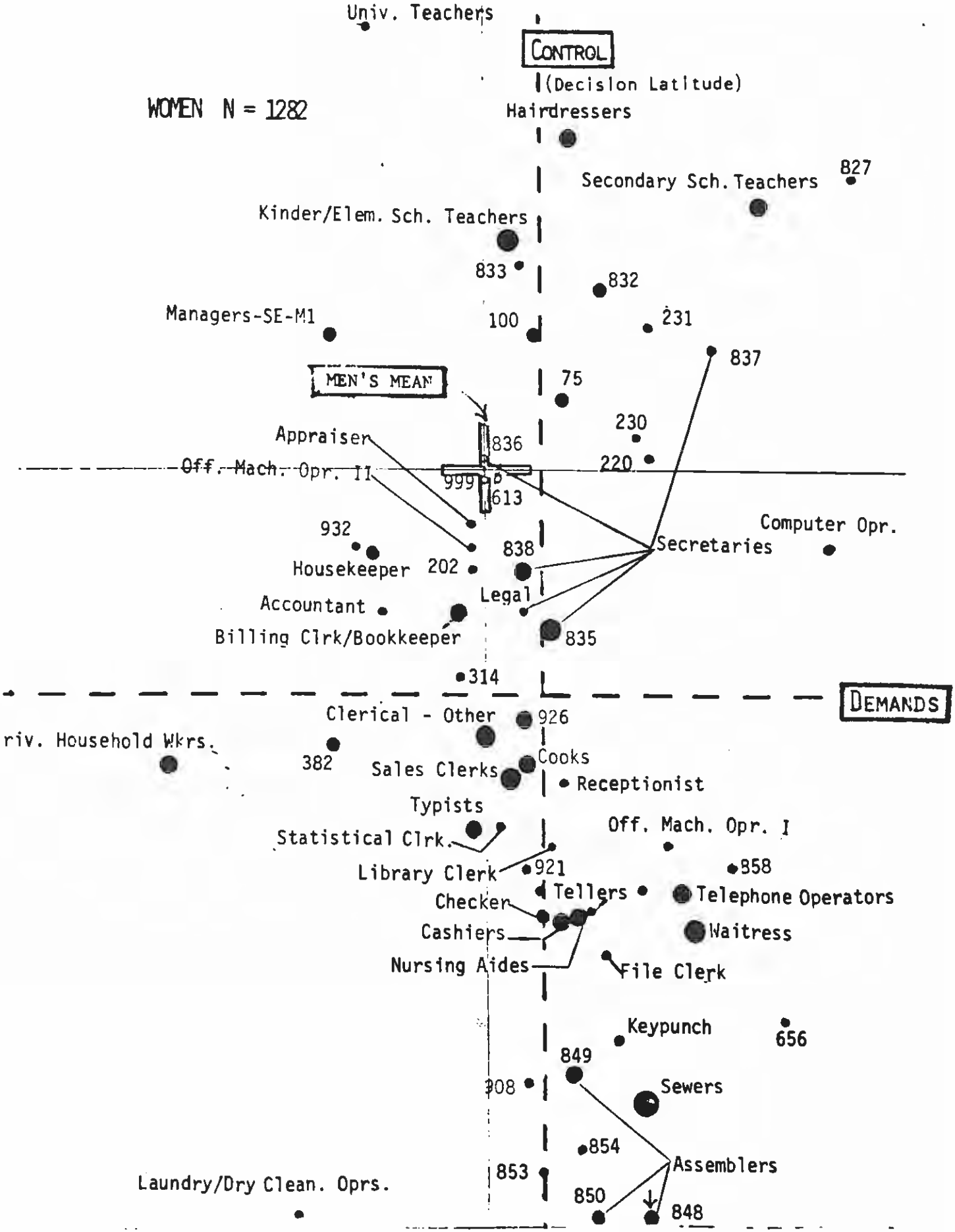
3. Comparing Men's Jobs and and Women's Jobs

Analysis of sex differences in job characteristic profiles for men and women with the same occupation is difficult, because there are relatively few occupations with large proportions of both sexes (at least of occupations large enough to represent over 0.1% of the work force in our sample). This, in itself, suggests that the process by which individuals come to occupy particular jobs may be the major cause of sex differences in job characteristics. However sex comparisons can be made by comparing the overall distributions of male and female dominated jobs in Figures 4 and 5. First it must be noted that women's mean decision latitude is markedly lower than men's (women's mean relative to the men's scale is shown in Figure 5) confirming similar results from other studies(see Wolf and Fligstein, 1979a, and Wolf and Fligstein, 1979b, on job authority). Althogh psychological demands at work do

not differ markedly for men and women, Figure 5 indicates a substantially greater (negative) correlation between decision latitude and demands for women. The majority of women's high demand jobs also have low decision latitude, whereas large numbers of high demand jobs have high decision latitude for men. This implies a much higher proportion of high strain jobs (and a lower portion of "active" jobs) among occupations where women predominate (Cranor, Karasek and Carlin, 1981). It is also interesting to note that a high proportion of the jobs created in the economy in the past two decades have been in these occupations (Stanback et al 1981) such as telephone operator, key punch operator, data-entry operator - often filled by women and confirming the pattern of job content change toward high "stress" work. Indeed these occupations are located quite close in Figure 6 to the classic "sweatshop" occupation: garment stitching. It is alarming to wonder whether the coming "office-automation" revolution, involving machine paced work on the computer-based systems, will continue this trend.

Figure 5 MEAN JOB CHARACTERISTICS SCORES BY 1970 (CENSUS) OCCUPATION CODES

(U.S. QUALITY OF WORKING LIFE SURVEYS 1969, 1972, 1977)



CORRECTING SCORES FOR DEMOGRAPHIC COVARIANCE, MODELLING PROCEDURES, AND OCCUPATION LEVEL ANALYSIS

E. ESTIMATING JOB CHARACTERISTICS SCORES FOR OTHER SURVEYS

Researchers have used a variety of techniques to deal with the problem of a dataset missing data for a crucial variable. Jencks et al. (1972) combine correlations from different datasets into a single amalgamated correlation matrix and then use it for testing structural equation models. Unfortunately, this method can be extremely sensitive to differences in population definitions between surveys; and parameters of the structural equation model can be significantly affected by population differences in the variance of some variables, (Duncan 1975). Similarly, economists at the Brookings Institution (Pechman and Okner, 1974) combine tax and social security government records for one sample of individuals with data from a Census Bureau Current Population Survey of different individuals in order to construct complete hypothetical data. However, the validity of such "merged file" approaches for individual analysis is still an unresolved question, since the data which could provide direct validation of the method is precisely what is difficult to obtain. Our approach to the problem of missing job characteristic data is to use the nationally representative Quality of Employment Survey to derive estimation equations for the various job dimensions that are a function of Census occupation code and can be used to estimate scores for individuals in other target databases where only

Table 7 : Comparison of total Variance Partitioning Using Mean Scores and Demographic Covariate-Adjusted Scores for Job Characteristics Quality of Employment Surveys 1969, 1972, 1977 (N = 2,857)

	ANOVA MODEL		ANCOVA MODEL			Total Measurement Error
	Between Occ. Eta^2	Between Occ / Total Reliab.	% Increase due to Demographic Covariates	Occupation + Demographic Between Occ / Total Reliab.	Remaining Within Occ Var	1.0 - Total Reliab. Variance
DECIS. LATIT.	51.9	47.8	2.2	55.3	31.2	33.2
- SKILL REQ.	33.9	50.7	1.6	54.9	30.2	33.1
- AUTHORITY	19.6	36.0	1.6	38.8	33.3	45.6
PSYOL. DEMND	5.6	10.6	5.1	20.5	42.0	47.2
HOURS	20.6	20.6	3.9	26.7	73.3	0.0**
JOB INSEC.	9.1	36.7	1.5	46.8	13.2	75.2
SUPPORT	4.0	4.8	1.4	6.4	78.5	16.1
- COWORKER	2.1	2.9	0.9	3.9	68.9	28.3
- SUPERVISOR	2.8	3.4	1.1	5.2	77.9	17.8
PHYS. EXER.	25.8	25.8	0.9	27.5	72.5	0.0**
NOISE	9.6	10.0	0.5	10.9	85.5	4.0**
TEMPERATURE	6.0	6.2	0.4	7.1	89.7	3.4**
HAZARDS	18.0	18.0	0.7	18.8	81.2	0.0**
(HOSTILITY)	18.3	22.0	0.1	22.8	64.2	16.8**

*The estimates in columns one and two differ somewhat from those in the rest of the columns due to slight differences in missing values and included occupational groups.

**No estimate of within survey reliability since job characteristic based on one indicator.

occupation data is available.[30]

The occupation-based estimation approach for job characteristics has the advantage of using direct occupational information about each respondent, but also has a crucial problem: that the occupation's aggregate score will fail to replicate much of the individual variation in jobs - as is indicated by the non between-occupation variance statistics in Table 7. Some of this missing variance, specifically some portion of the within-occupation variance, could distort (bias) regression equation results for individual level analyses. Other sources of missing variance, notably unreliable scale variance, should cause few problems beyond the lack of score precision. We discuss these complications below.

1. Unreliable Variance

Since most of our job dimensions are operationalized as scales, based on a sum of responses to several indicators, we can estimate their reliabilities (Cronbach alphas). These were discussed in Karasek, Schwartz and Pieper 1982, and are presented in Table 7. The reliabilities of our scales (with the exception of job insecurity) are between 0.55 and 0.85, acceptable but not

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[30] In our opinion many researchers have, in effect, used some version of this estimation process, often without realizing some of its implications. For example, the Duncan socio-economic index (SEI) was developed as an estimation equation of NORC prestige scores for one set of occupations, which could then be used to impute prestige scores for other occupations (Duncan, 1961). Even the NORC scores themselves (Gusfield and Schwartz, 1963;NORC, 1947) are estimated prestige scores for individuals in particular occupations: few of us would claim that all persons in a specified occupation have the exact same occupational prestige. Rather, a NORC score is an estimate of the average prestige accorded those in a given occupation. It specifically ignores all/any within occupation differences among individuals. These comments do not imply that the use of NORC prestige scores or Duncan SEI scores is wrong, but rather that some users of these scales may over-interpret the concreteness of their indicators: Hauser and Featherman suggest that SES is whatever Duncan scores measure, rather than treating Duncan scores as an indicator of a previously defined concept - socioeconomic status (Featherman and Hauser, 1976; Hauser and Featherman, 1977).

extremely high. Scale unreliability, while certainly undesirable, is somewhat less problematic for our approach than it is for many types of analysis. That is because much of the measurement error is "averaged out" by the estimation process. In particular, this variance is not expected to vary systematically across occupations and should therefore not bias the job score estimates. Thus, the primary effect of unreliability is to increase the standard errors of estimated job dimension scores.[31]

2. Within-Occupation Variance

Table 1 also shows the percentage of reliable within occupation variance for each job characteristic. In general the occupation means of a job dimension do not account for the majority of the reliable scale variance: the between occupation variance is 51% at most (skill discretions) and substantially less for some scales. The possible sources of within-occupation variance vary considerably in their methodological and policy implications.

1. Variation in objective task within occupations

Detailed task differences could be due to different work organization stategies within different industries or establishments for the same occupation: (bakers in an expensive French pastry shop vs. assembly line "bakers" at a Wonder bread factory). We cannot easily estimate how much variance is lost going from a "most detailed" job classification scheme which could capture such differences to our Census occupation codes.[32] However it is of interest to observe that in going from the 584 Spenner occupations (1980)

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[31] The relative increases in the standard error depends on the ratio of the unreliable variance to the (reliable) within-occupation variance. Specifically, the proportionate increase in the standard error, (reduction in the precision of our estimates) equals:

$$\left(\sqrt{1 + \frac{\text{unreliable variance}}{\text{within-occupation variance}}} - 1\right).$$

[32] It will be recalled, earlier in this paper, that we have collapsed the detailed Census codes into about 211 occupational categories.

to our 211 occupations, about 5% of the between occupation variance of DOT scores is lost. This implies that a truely detailed job classification system (DOT has 12,099 occupations) might substantially increase the "between-occupation" variance of our system (but would require a much larger data base than the QES to estimate scores). This type of within occupation variance should be associated with health outcomes in the same manner as the presently measured between-occupation variance. Our individual level predictions using the job scores would be strengthed if such assumptions were correct.[33]

2. Unmeasured variables relevant to health (correctable)

This second source of within-occupation variance could cause substantial methodological difficulty when occupationally aggregated scores are used to estimate individuals' job characteristics. Some of the missing between-occupation variance may be due to factors that also affect the health outcomes. For example: age affects cardiovascular illness, and there are surely age differences between occupations (older docters, younger orderlies), which affect the task authority of individuals. In multivariate causal modeling, associations between task authority and cardiovascular illness would be affected by the "missing" within-occupation variance of job scores that is associated with age. Stated differently, age may partially serve as a proxy variable for the "true" effects of task authority differentials which are not captured by the estimates. Non-job factors which might have such effects include social allocation "variables" affecting "rights" (not always legitimate) to certain job circumstances: age (seniority), education, race, and sex. Alternatively, some characteristics of the individual may affect job performance (age, education, physical dexterity), or may affect job selection mechanisms. Since confounding factors are potentially very important, our scoring system is designed to specifically circumvent this type of problem, at

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[33] These sources of variation have different policy implications for our research. Source #1 variance has the same role in our theoretical model as (predictable) between occupation variance: that is, they both reflect variation in components of the work situation/environment that may affect health. To influence these outcomes social policy should be directed towards a restructuring of the work environment.

least with respect to the demographic factors of age, race, education, marital status, self-employment, region, and urbanicity (sex is held constant). This methodology is the primary focus of this paper and is described below.

3. Exogenous sources of variance (not corrected)

We cannot correct for all potentially confounding variables that may account for some of the within-occupation variance in our job scores. This is primarily due to a lack of information on the QES and the target data bases where our scores might be applied. For example, non-demographic individual differences in "genetic complement," family background (net of education) or personality orientations might affect both job selection and health outcomes, but are beyond the scope of our data and focus. It should be noted, however, that there is often little agreement as to how to measure such variables, even "intelligence," (see discussion Jencks et al [1972], Chapter 3), and still less agreement exists as to relevant personality factors. If these factors were characteristic of an entire occupation, their omission could bias our conclusions.[34]

4. Perceptial bias in job score reports

Another source of variance in the within-occupation scores may be considered as a type of non-random (systematic) measurement error - at least for the goal of assessing "objective" characteristics of work circumstance. The worker is the source of the job data and may distort the reporting of his/her job characteristics, such as psychological work load. While this could bias results of individual level analyses, it should not cause a problem for occupationally aggregated scores, because we would not expect these "biases"

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[34] Variance in our true job scale scores that is attributable to sources #3 or #4 is not likely to be the focus of social policy since it is based on characteristics of the individual rather than the job. (One exception is Glass's [1977] proposal to modify individuals' "Type-A behavior" - a personality factor in this context - in order to reduce stress.)

to vary systematically by occupation. For example, we would reject the contention that butchers as a group characteristically perceive their job autonomy to be lower than their "objective" autonomy levels, while bakers as a group systematically overestimate their "true" autonomy (the operational assumption on our part is that the essential source of report bias is individual differences).

F. THE ESTIMATION PROCEDURE TO ADJUST FOR THE CONFOUNDING EFFECTS OF DEMOGRAPHIC FACTORS ON INDIVIDUAL LEVEL ANALYSES

The simplest estimate of an individual's score on some job dimension is the average score of all individuals in the same occupational category. The idea of imputing group means has been used occasionally before, (Sales and House, 1971) and is still used with success (Rainwater, 1974; Coleman et al., 1978). In order to implement this procedure we merely need to calculate from the Quality of Employment Survey the mean of the job dimension for each occupational group. Each individual in some second survey (which lacks data on working conditions) is assigned the QES mean for his/her occupation on that job characteristic.

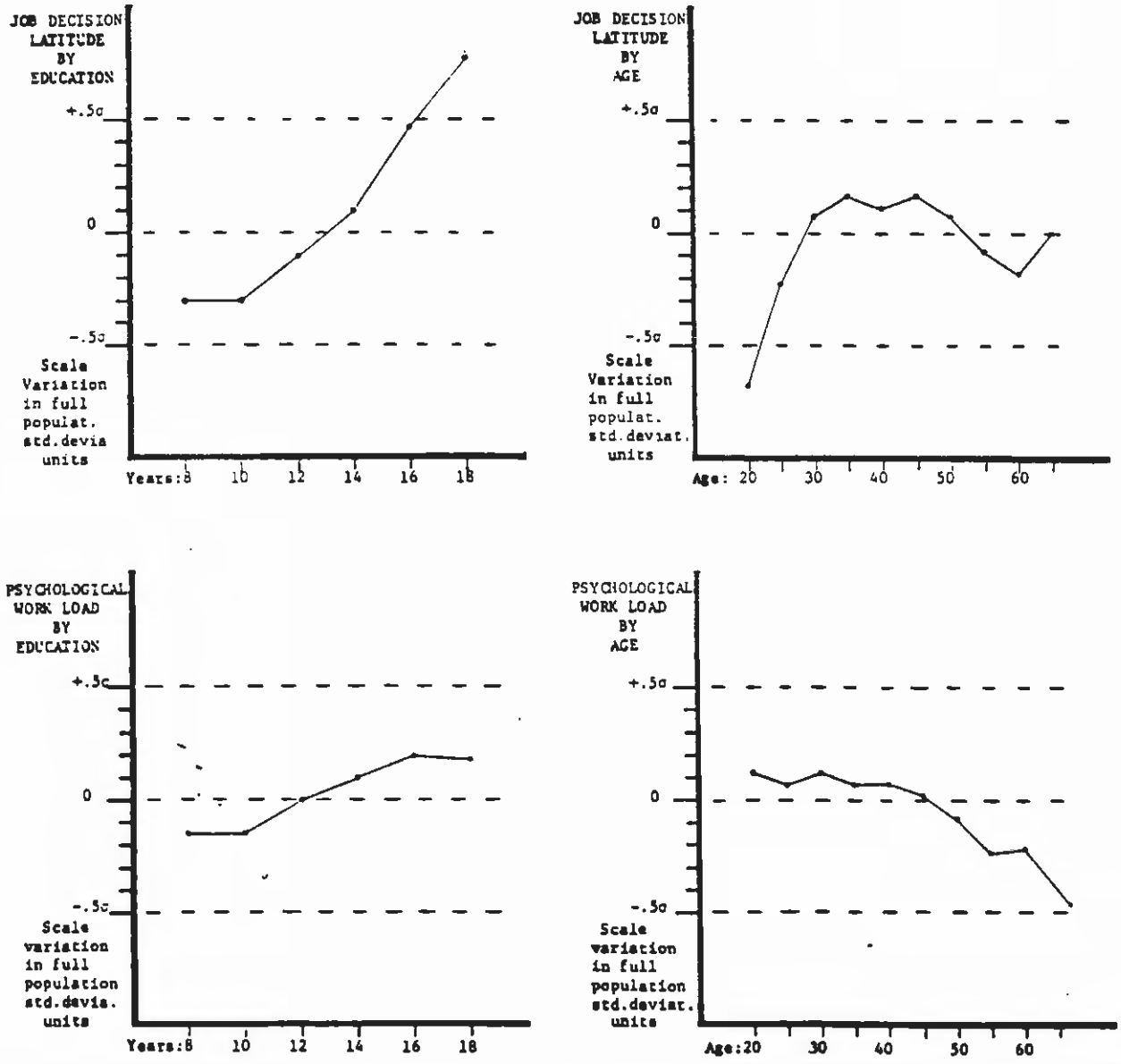
$$\hat{Y}_{ij} = \bar{Y}_{.j}, \qquad \text{(III.1)}$$

where the predicted score of the i-th person in occupation j is the average of all persons in occupation j. The statistical model underlying this estimation procedure is the one-way analysis of variance (ANOVA). Interpreting these estimation procedures as an application of the ANOVA model additionally permits us to estimate how much of the variance of a job dimension is between occupations (and is therefore captured by the estimates) and how much is within occupations (and therefore lost by this estimation procedure). Conventional statistics also yields estimates of the unreliability (error due to sampling variation) of the sample group means as estimates of the

Figure 6

COVARIATION OF SELECTED JOB DIMENSION SCALES BY AGE AND EDUCATION

(Q.E.S. SURVEY N=2,857)



population group means.[35]

Two drawbacks of the ANOVA model have caused us to further elaborate the ANOVA estimation procedure. As stated above, this simple model uses the within occupation means, which are the expectations of a job dimension conditioned on the occupational category. In general, we anticipate that the various job dimensions vary according to several possible demographic factors in addition to occupational category. For example, age and educational attainment are often associated with our job dimensions, [even within (controlling for) occupational groups], as can be seen in Figure 6 in the case of decision latitude and psychological job demands. When this is true and the demographic variables are available in both the QES and the target surveys then it is possible to obtain improved estimates of the job characteristics by conditioning them on both occupational category and demographic characteristics. Table 7 shows that incorporating demographic variables does improve the predictive power (percent of reliable variance accounted for by occupation and demographic variables) of the resulting estimates, although sometimes only marginally. In general, for the job scores with substantial between occupation variance (decision latitude) the increment due to demographic factors is small, but for several dimensions in which between occupation variance is low (psychological job demands and job insecurity), the increment is substantial.

The second, methodologically more important, argument for including additional variables in the estimation procedure is to reduce bias in the estimate of the effect (on some outcome measure) of a job characteristic that would occur in causal modeling if other variables are associated with both the outcome measure and the job characteristic. For example, any analysis of blood pressure must begin by controlling for age, which is a major blood pressure covariate that is also correlated with several job characteristics.

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[35]Given our use of detailed occupational categories, the standard errors of the group means of the smaller occupations will be quite large; see p69.

If job scores, uncorrected for age, are included along with age in a regression analysis of blood pressure, age will partially serve as a proxy variable for the component(s) of job characteristics which were not captured in the estimation procedure used to construct the job characteristic scores. Correctly estimating the direct effects (regression coefficients) of several independent variables depends on having valid estimates of the associations (covariances) among the independent variables. In general, using the ANOVA job score estimates will yield underestimates of the covariance of the actual job scores with demographic variables and/or other confounding factors that also affect the dependent variable. This can be particularly problematic when job scores are estimated (from occupation) and the demographic or confounding variables are measured directly - as would be the case on most of our target data bases. In this circumstance, if there is some correlation between the true (underlying) job scores and demographic variables, the effects of job characteristics will be biased toward zero (underestimated) and the demographic variables will be biased away from zero (overestimated) when these variables are introduced simultaneously into a regression analysis. This is because the ANOVA estimates capture only that portion of the covariance, with other variables, that is between occupations, while missing the within occupation covariance. However, by incorporating demographic variables (in addition to occupational category) into our estimates of job scores, through simultaneous estimation proceedures, our estimates will fully replicate the individual level covariance between the job dimensions and the demographic variables. This is the goal of the job characteristic estimation procedure described below.

The statistical model used to simultaneously condition estimates of a job dimension on both a categorical variable (occupation) and interval level variables (age, education, etc.) is analysis of covariance. The ANCOVA estimate of an individual's score will take the form

$$\hat{Y}_{ij} = \bar{Y}_{\cdot j(adj)} + \sum_k B_k (X_{ijk} - \bar{X}_{\cdot\cdot k}), \qquad \text{(III.2)}$$

where $\hat{Y}_{ij}$ is the estimated score of the i-th individual in occupation j, X_{ijk}

is this individual's score on the k-th covariate (demographic or confounding variable), $\bar{X}_{..k}$ is the grand mean of the k-th covariate, B_k is the unstandardized regression coefficient (controlling for other covariates and occupation) for the k-th covariate, and $\bar{Y}_{.j(adj)}$ is the adjusted (for covariates) within group mean for the j-th occupation.

The confounding variables simultaneously available in the Quality of Employment Surveys, the national health surveys, and, we suspect, most other major surveys are limited to major demographic variables: age, years of education, marital status, race, urban/rural, geographic region (South/Non-South), and self-employed/employee.[36] Sex is held constant by only analyzing males.[37] Where the evidence warrants, we also use non-linear transformations of age and education in order to incorporate into our estimates any non-linear relationships between a job dimension and age or education.[38] The coefficients of the covariates (the B_k) for estimating the job characteristic scores are

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[36] Although several of these variables are categorical, they are easily treated as covariates through the use of dummy (0,1) variables.

[37] It would, of course, be possible to incorporate sex as a covariate into the present analysis. However, it seemed likely that the differences between the sexes would vary by occupation and, possibly, the other covariates. Although such differnces could also be incorporated into the estimation procedure, through the use of appropriate sex-interaction terms, it seemed less complicated and more reasonable to initially apply our estimation procedure separately to males and females. The female analysis is currently in progress and we hope to compare it with the present male analysis in the near future.

[38] The relationship between the demographic variables and work conditions may be different for blue collar and white collar workers: job discretion might increase more per year of education for managers than it does for truck drivers. Preliminary analysis to be reported in a future publication shows some of these differences to be significant. We began with fifteen occupational subgroups, and attempted to consolidate these groups into a small number of "classes" - on the basis of consistent "interactions" between demographic variables and job dimensions. This proved to be a difficult task: no consistent small set of new "classes" so defined could be easily identified.

Table 8 Regression Coefficients** For Demographic Covariates In Analysis of Covariance By Occupation (Occupation As Factor) - Using G.S.S. 1968, 1972, 1977

	Age	$(Age)^2$	Over 25	Over 30 (slope)	Over 65 /	Educ.	$(Educ)^2$	Credential	Marital Status	Alone	Race	Self-employ	South	Rural	R^2 adj Demographic Regression	N
Decis. Latit.				.2294*		.3508*			2.493*			3.048*			.021	2792
-Skill Req.						.2017*			1.643*			.0951		.4081	.016	2810
-Authority				.1539*		.1404*			1.085*			2.108*			.016	2805
Psyc. Demand	-.0794*				-2.813*	.0906				-1.127*	.0849	1.722*	-1.026*		.051	2689
Hours	-.0961*	-.0006*					.0288*			-1.875*	2.761*	5.549*			.039	2836
Job Insecur.	-.0032			-.0196*							-.1107				.015	2792
Support	.0038											.3477*	.1911*	.1350*	.014	2823
-Coworker	.0029												.1399*	.0406	.003	2811
-Supervis.								.1905*					.1146*	.0842	.011	2194
Phys. Exer.	.0038					.0253*						-.2578*			.009	1911 ***
Noise													-.0432*	-.0316	.005	2870
Temperature	-.0059			-.0064*											.004	2870
Hazards							-.0027*					.1380	-.0975*		.007	2870
(Hostility)															.001	2870

**unstandardized coefficients

* $P \leq .01$ (otherwise all coefficients $\leq .05$)

*** no data 1977

shown in Table 8. In general, the overall variance due uniquely to these factors is not large, never exceeding 5% of the variance (net of occupation - see Table 7), but for some job scores (notably psychological work load) its effects are still substantial. To briefly summarize the overall pattern of the associations in Table 8: decision latitude appears to be most affected by education and marital status. Age seems to have its greatest effects on work load and stressors. Job social support is significantly affected by being in the South (an unexpected association). Self-employment has the most consistant impact of any of the confounding variables - and indeed might itself be considered a "job characteristic" in some analyses.[39] Two advantages of explicitly thinking of these estimation proceedures in statistical terms are first, that one remains sensitive to the within-occupation variance that the estimates fail to capture and, second, it becomes possible to estimate the standard errors of the estimates. Because of its more technical nature, the discussion of standard errors is relegated to Appendix V.

G. USE OF THE METHOD FOR INDIVIDUAL-LEVEL ANALYSES

1. Conceptual Models

The conceptual basis of the methodology behind the demographic adjusted occupation-based scores, adjusted for demographic characteristics, is outlined in Figures 7 through 9. It must be remembered that the method is being used to adjust individual-level job scores and to use them to predict effects of job characteristics at the individual level. The model in Figure 7 corresponds to Equation 2 and its parameters are estimated from the Quality of Employment Surveys. The coefficients of related demographic variables for each of our job scales are shown in Table 8. These estimates (including the adjusted occupation means) are used to calculate predicted job scores in other

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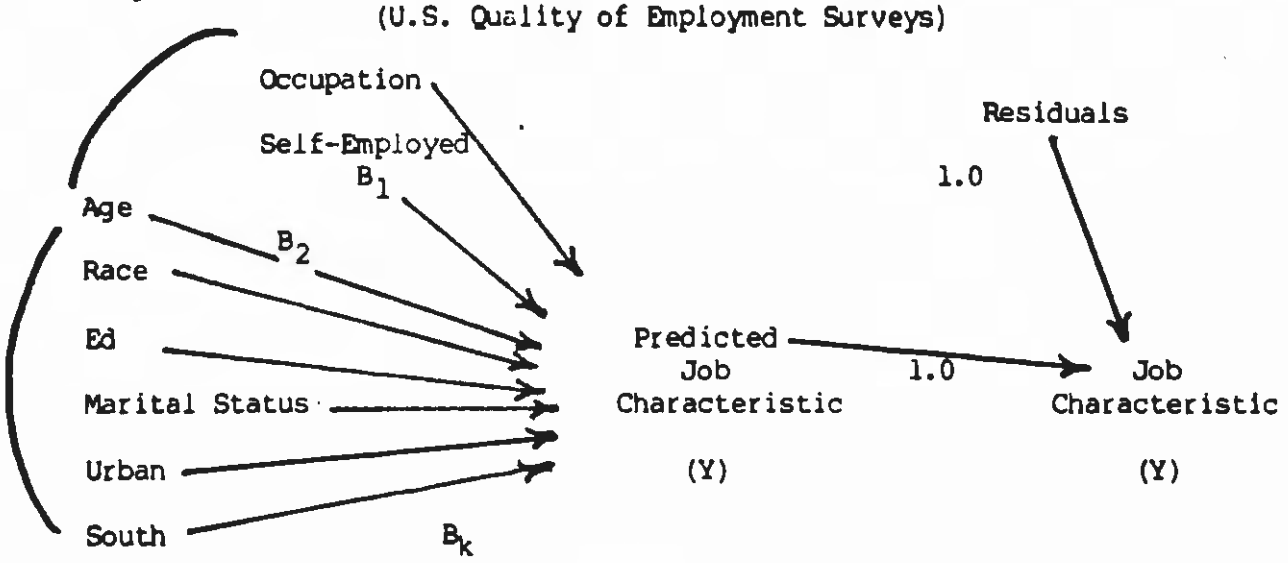
[39] What differentiates self-employment from our other job characteristics is only that it is generally available in other surveys and therefore we have no need to try to estimate it.

Figure 7 .: Model for Estimating Job Characteristics of Occupations (U.S. Quality of Employment Surveys)

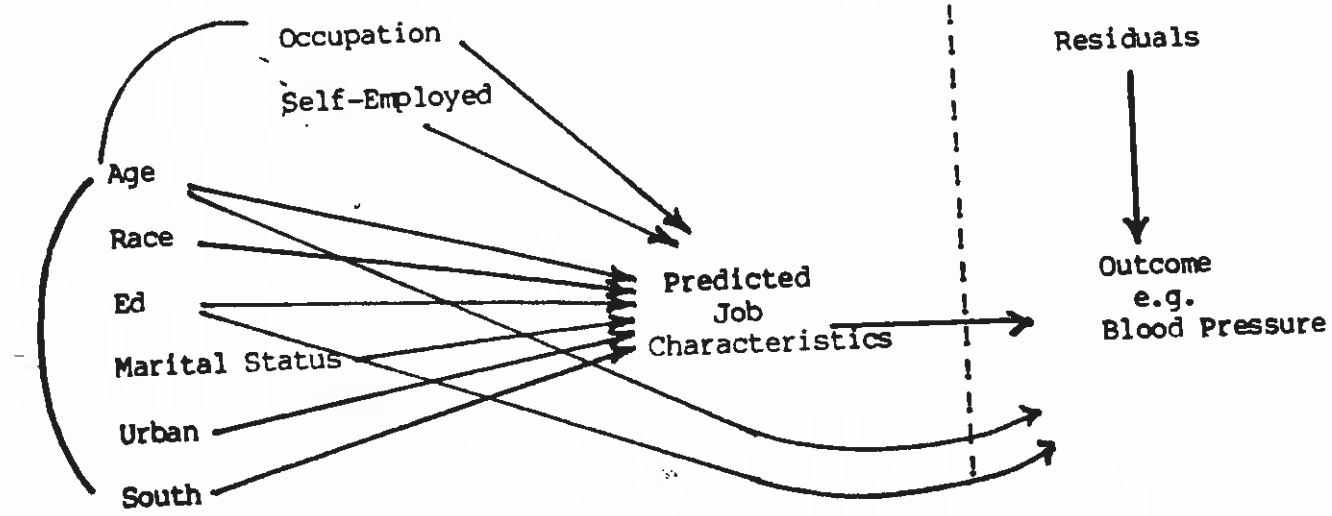


surveys that therefore have the same relationship to the demographic variables and occupation as exists in the QES (left portion of Figure 8). These scores are then used with the demographic variables to explore possible associations with the outcome variables (right portion of Figure 8).

Figure : Model for Use of Estimated Job Characteristics to Predict

Figure 8

Model for Use of Job Characteristic Equations in Surveys with Outcome Variables



This procedure is formally analogous to two-stage least squares with occupation acting as an instrumental variable. We are hypothesizing that the

effects of occupation on the oucome variables are mediated through a few specific job dimensions.[40] The statistical theory of two-stage least squares can be applied to infer that the ordinary least squares estimates of the parameters (coefficients) of our outcome variable equation:

$$Z_i = \alpha' + \sum_k \gamma_k' X_{ik} + \delta' Y_i + \epsilon_i \qquad \text{(III.3)}$$

are unbiased estimates of the parameters of the equation

$$Z_i = \alpha + \sum_k \gamma_k X_{ik} + \delta Y_i + \epsilon_i \,, \qquad \text{(III.4)}$$

which we would be estimating if our second survey included measures of job characteristics (Y).[41]

Although our estimate of an individual's job score will be unbiased, the variance of the estimated scores will be very substantially less than the true variance of the job dimension, (Y). This is directly attributable to the within occupation variance that cannot be captured by our estimates. The restricted variance of our estimated independent variables makes them much less efficient[42] for predicting outcome variables than if we had job characteristic variables measured on the same survey as the outcome variable. As we will show below, this missing variance will also reduce the R^2 of the equation predicting an outcome variable; that is, because of the reduction in variance, the estimated job scores cannot account for as much variance of the

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[40] The plausibility of this assumption can later be examined by testing for significant between-occupation variance in the residuals of the outcome variable equation.

[41] Of course the validity of this inference depends on the validity of the assumption that the relationship in our target survey of the unmeasured job characteristics with occupation and the demographic variables is the same as in the QES. Any method that uses results from one survey in the analysis of a second must rely on an assumption of this type.

[42] This means that the standard error of the regression coefficient will be relatively large, thereby reducing the power of any significance test.

outcome variable as the actual job scores could.

Using the results of the previous sections and Appendix I, one can use a latent (unobserved) variable model to estimate how much of the variance in an outcome variable would be accounted for if we had measurements of respondents' actual job characteristics. This should be greater than the results obtained from using the estimated job scores precisely because of the reduced variance of the estimates. The estimated increase in explained variance is an estimate of the variance accounted for by within-occupation variance in the job characteristics and is one measure of the "cost" of not measuring job characteristics in the same survey as the outcome variable.

Figure 9 Estimating Effects of Lost Variance in the (Estimated) Job Characteristic Scores

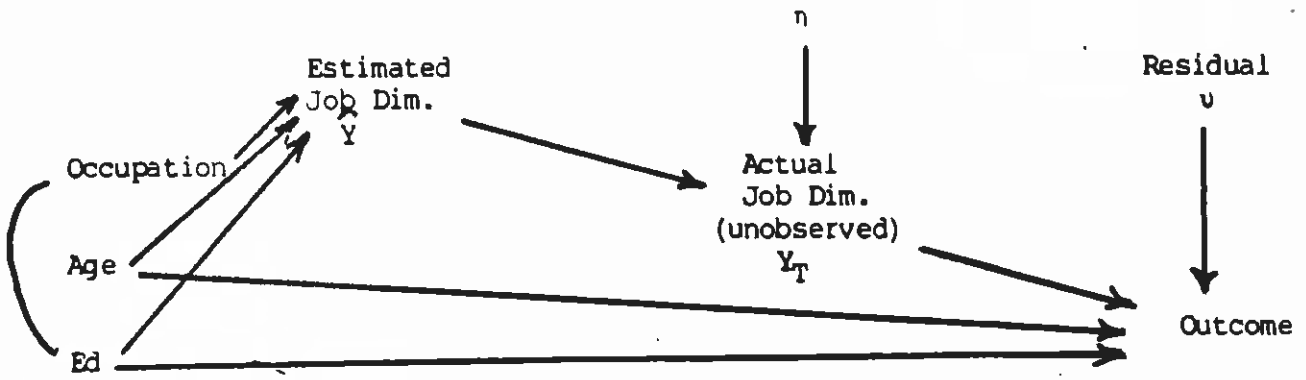

Figure 9 illustrates a simplified version of this latent variable model. Once again, the importance of the ANCOVA model estimates of Y becomes apparent. The residuals (η) of the ANCOVA estimates are uncorrelated with $\hat{Y}$ and the (demographic) variables that were used as covariates to predict Y_T. This legitimizes the assumption that η is uncorrelated with the exogenous variables. Thus, given an estimate of this within-occupation variance (σ_η^2), this model is identified and easily estimated.[43] In fact, the estimated

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[43] The significance of the covariates in the ANCOVA equations demonstrates that the residuals from the ANOVA model estimates would not be orthogonal to the demographic variables. Without the assumption of orthogonality, this latent variable model is grossly under-identified. Stated differently, regression estimates based on a false assumption of the orthogonality of these residuals with other determinants of the outcome variable will be biased.

regression coefficents and their standard errors are identical to those in Figure .. The only difference is that σ^2_U will be smaller because more of the variance of the outcome variable will be accounted for by Y_T.

Some readers might suggest that if this latent variable model can estimate the result of collecting job characteristic information from respondents, then there is no need to collect such data. There are four primary reasons that individual data are needed:

a. This model only provides estimates of the results that would occur if the second survey had individual level job characteristic data;

b. This model assumes that the empirical relationship of the job characteristic to occupation and demographic variables is the same for the populations sampled in the second survey and the QES (see footnote 10);

c. These estimates are based on the untestable assumption that the between-occupation and within-occupation (i.e. predictable and unpredictable) variation in job characteristics have the same effect on the outcome variable;

d. The reduced variance of the estimated job characteristic scores make the model estimates less stable (by increasing the standard errors) and this reduces the power of significance tests and the overall precision of our conclusions.

2. Validating the Job Scoring System

The validity of the above described job scoring system should be measured by its ability to reproduce the results which would be obtained with individual level job characteristic data. Obviously, if our second survey contained this latter type of data, we would have had no reason for developing an occupation-based scoring system in the first place. Instead, we have compared the ability of estimated job characteristics to replicate an equation predicting a general depression scale available in the Quality of Employment Surveys (Quinn 1977) from individual level job data and demographic variables. The details of this analysis are being reported elsewhere (Schwartz and Pieper, 1981) but will be summarized here. Using individual level job variables, four demographic variables (marital status, south (region), age,

and self-employment) and two job characteristics (social support and decision latitude) were found to be simultaneously related to general depression. When we ignored the availability of individual level job scores and only used the ANCOVA-model estimates of job characteristics (the job scores used in our system), the exact same variables (and no others) were again found to affect depression. While the R^2 for the second equation was only about 47% as large as for the first equation (due solely to the lack of within-occupation variance on the two estimated job characteristic variables) the application of our latent variable model (Figure 9), estimated using LISREL, produced an R^2 for depression that was virtually identical to the original individual level equation. Furthermore, when we compared corresponding regression coeffcients from the two equations, the coefficients of the two job characteristic variables differed by an average of half a standard error while the coefficients of the demographic variables differed by an average of 0.07 standard errors. [The regression coefficent for social support using direct individual data was 0.0371 (standard error 0.0033) vs. 0.0403 (standard error 0.0090) using ANCOVA-corrected estimates. The respective coefficents for decision latitude were 0.0026 (standard error 0.0004) vs. 0.0021 (standard error 0.0006)]. It is interesting to note that the effectiveness of the estimated scores does not seem to be particularly dependent on the amount of between-occupation variance for the job characteristic dimension; in particular, decision latitude has a rather high between occupation eta^2 of 0.51 but social support has a very low value (Table 7). Overall, the direction and magnitudes of the difference for each pair of coefficients appear random (except that the differences are smaller for the demographic variables) and have no impact on the substantive conclusions one would draw.

We also estimated a depression equation using ANOVA-model estimates of the job characteristic variables in order to determine if the ANCOVA-model estimates are indeed superior. The differences however are not large, but they exhibit the predicted pattern. The coefficients for the ANOVA-model estimates of social support and job discretion differ from those of the individual level variables by an average of 0.6 standard errors and, consistent with our prediction of downward bias, both of the former are closer

to zero. The corresponding coefficients for the demographic variables in the two equations differ by an average of 0.4 standard errors with the direction being consistent with a prediction of upward bias for the equation using ANOVA-model estimated job scores. In particular, it is the coefficients of south and self-employment - the two demographic variables that are most correlated with social support and job discretion - that deviate most from the coefficients of the "individual level" equation. In summary, we conclude that the ANCOVA-model system where scores are corrected for demographic covariance replicates the corresponding individual level analysis quite well. It, furthermore, does this somewhat better than the simpler ANOVA-model system based on occupational means alone.

H. OCCUPATIONAL LEVEL ANALYSIS

1. Selecting Occupations at Risk: A Question of Reliability

The job characteristic scoring system should potentially be useful for occupation-level analysis, as well as individual level. A typical research problem might be to predict/determine which occupations have the highest level of a particular health problem; e.g. high blood pressure or psychological strain. Differences between occupations with respect to disease prevalence could then be related to the occupation's mean level of job risk factors through use of our job characteristic scoring system. (Here adjustments for individual differences and within occupation variance are no longer necessary - unless the database must be standardized for a special sample population.)[44]

Obviously, two independent sets of criteria could be used to select occupations at risk: based on either the health variable itself, or on confirmed job-related, "risk factors". If reliable estimates are available for the health variable for all occupations, the dependent variable may be used as the criteria, and its reliability (beyond the scope of our system) will be the critical parameter. Use of available health data for such a criterion may be difficult however; none of the U.S. nationally representative health surveys have sample sizes large enough to insure accurate blood pressure estimates for even a third of our (collapsed) set of Census occupation codes, (211 categories for males). The estimation of occupational coronary heart disease would reqire even larger samples. An alternative method is to validate a risk prediction equation, using job characteristic variables, at the individual level. Then occupations high and low on the combined risk factors can be selected. The critical issue then becomes how

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[44]Our (ANCOVA model) job scoring system permits one to estimate the impact on job characteristic scores that would result from demographic characteristics of a special sample (i.e. rural south, whites only). Appropriate adjustments could be made so that the new sample scores for each occupation could be compared to nationally representative scores for that occupation.

precisely job characteristics can be measured by occupation - (the standard error issue mentioned above). For experimental design, one would search a table of our job scores for occupations that are both extreme on the "risk" characteristics and have low standard errors. In such a manner our job characteristic scoring system could be used as an "occupational-targeting" methodology - to be used as the first stage of a later field study where individual level data are gathered on a more ecomonically sized sample population.

The crucial issue for such analyses becomes the reliability of each occupation's job characteristic score. The sampling variability due to both within-occupation variation and measurement error (unreliable variance) as well as the relatively small number of QES respondents in most occupations combine to increase the standard errors (for detailed dicscussion of standard errors see Appendix V). Reliabilities of the scores by occupation, are graphically illustrated in Figure 10. Again we plot occupation against two job dimensions: job decision latitude and psycholgical job demands, (which have had success in predicting psychological strain, see endnotes). For the occupation of watchman in Figure 10, for example, we can discuss two relability estimates. First, there is the 67% (plus-or minus one standard error of the mean) confidence interval for each occupational mean score. This is fairly small: 0.48 individual population standard deviation units for decision latitude, and 0.24 units for psychological demands (inner ellipse in Figure 10). This suggests that differences between scores for many occupations are statistically significant particularly where the occupation's size in the QES is large enough (the size of the dot in Figure 10 is proportional to the occupation size).

Returning our focus momentarily to individual level analyses, it is interesting to compare the reliability of individual level job score estimates with the above noted occupation level reliability.[45] We observe in Figure 10

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[45]This distinction is between the standard error of the estimate of an individual's score vs. the standard error of his/her occupation's mean.

that the standard error of estimated scores for individuals within the occupation of watchman is large: 0.75 individual population standard deviation units for decision latitude and 0.31 units for psychological job demands. Thus, approximately 50% of the watchmen lie within the second ellipse, (radii = 0.67 standard errors of estimate) in Figure 10. This suggests that for many "adjacent" occupations we may often not be able to significantly differentiate job experience between individuals based solely on their occupations. This lack of precision in predicting an individual's job characteristics from his/her occupation is not surprising. Much of the variation in scores is based on known differences in task experience within an occupation, (recall job differences for the two bakers: croissant shop vs. Wonder bread factory). If we want to differentiate occupational experience on the basis of our scores we may well have to be satisfied with assertions based on rather loose approximations: "50% of the watchmen ...". However, using multiple job dimensions, individuals may be more easily discriminated. Using five job dimensions, even if the difference between two occupations' means on each dimension was only significant at the 0.25 level, the overall probability that these two occupations share the same point in the "five dimensional occupation space" (that their means are identical on all five dimensions), would be $p \leq (0.25)^5$ or $p \leq 0.001$, (this assumes independence of the dimensions; correlations among the dimensions would raise these probabilities). Of course, the more likely strategy for individual level analyses using our scoring system is to estimate associations and regression parameters for an entire population, as was illustrated in the previous section.

2. An Illustration of Occupational Level Analysis: Predicting Psychological Strain

Figure 11 is a plot of composite psychological strain[46] against two job dimensions which, in other individual level analyses, have shown strong

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[46]It is a sum of z-scores for depression (U. Michigan Affective Life Satisfaction), job satisfication, (U. Michigan Facet Free Job Satisfication), physical signs of psychological stress, and sleeping problems.

Figure 10

Mean Job Characteristics Scores By 1970 (Census) Occupation Codes

(U.S. Quality of Working Life Surveys 1969, 1972, 1977)

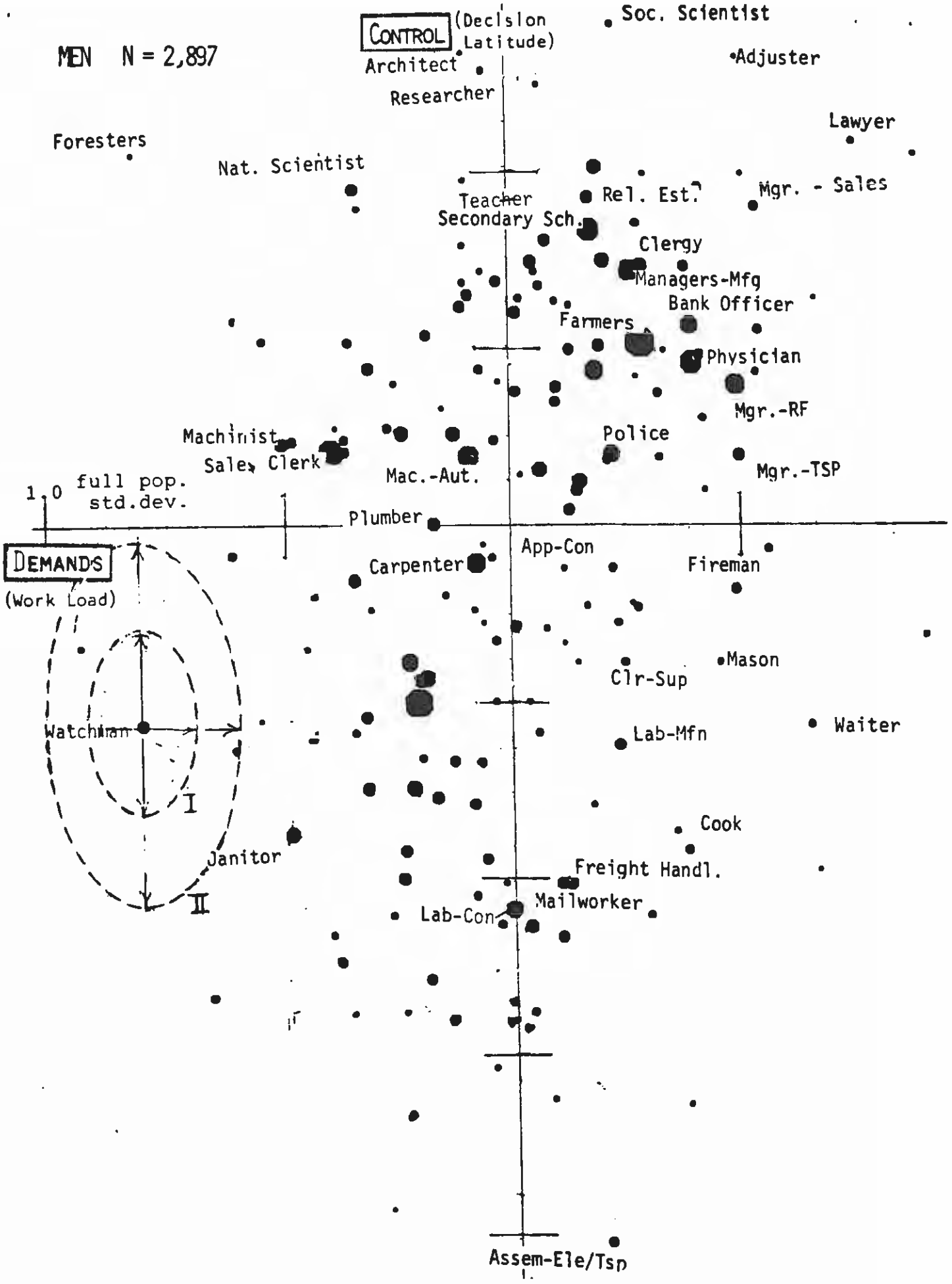

Figure 11

Composite Psychological Strain By 1970 (Census) Occupation Codes U.S. Quality of Working Life Survey 1972, 1977

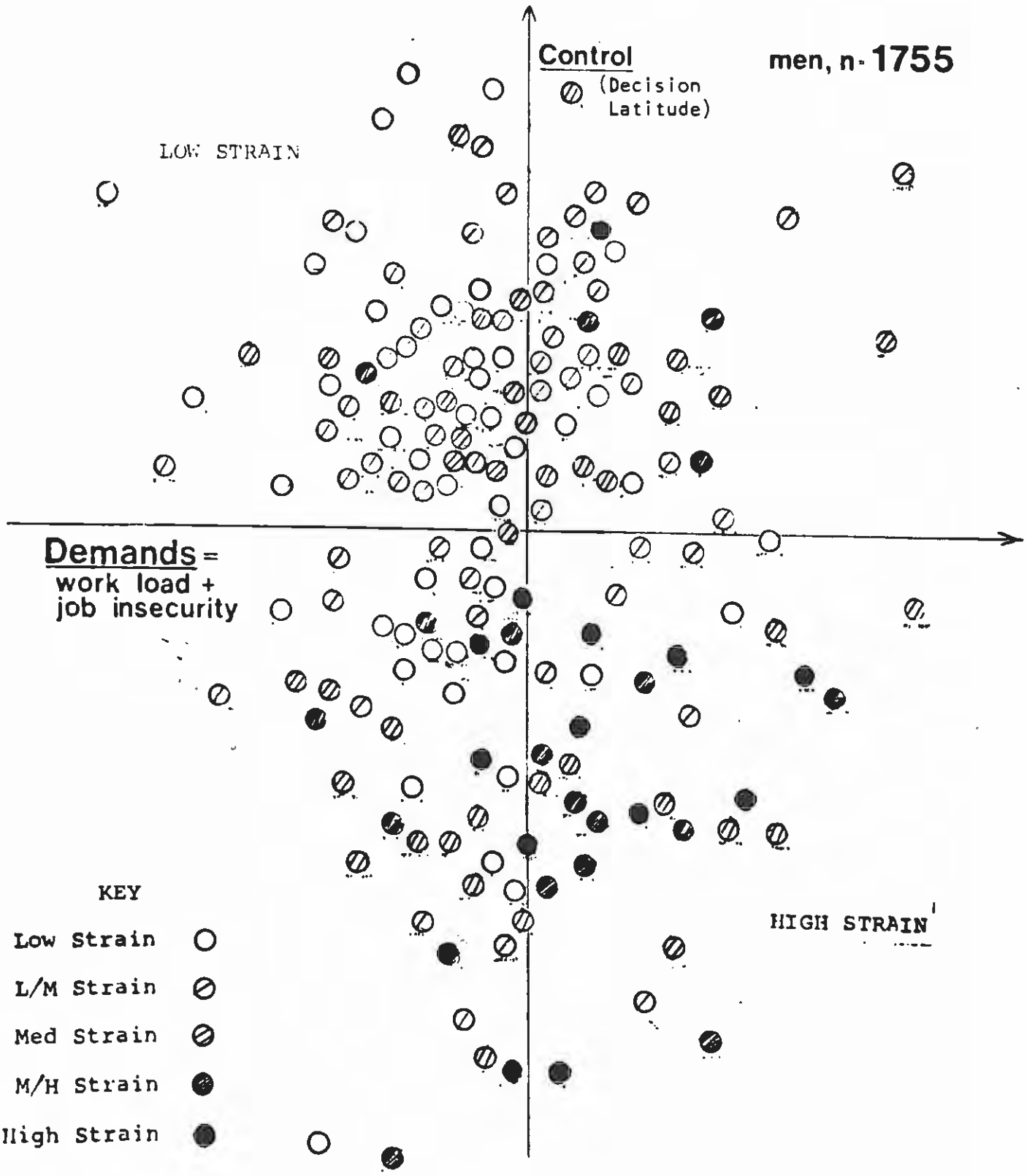

Table 9 :

Selected occupations in Two Job Risk Categories
Actual/Predicted Psychological Strain

OCCUPATION	CENSUS #	(N) QES	QES PHYSICAL DEMANDS	QES COMPOSITE PSYCH STRAIN
			I. HIGH STRAIN GROUP	(LOW DECISION LATITUDE, HIGH JOB DEMAND)
NURSES AIDES	925	6	3.000	.875
MASONS	410	9	2.600	.372
LAUNDRY OPR.	630	5	3.000	3.117
WAITER	915	10	1.500	1.789
LABORER-MFG.	858	13	2.000	2.455
EXCAVATORS	436	20	1.125	1.130
LABORER-FARM	822	31	2.167	- .649
STOCK HANDLER	762	6	1.000	.842
COOKS	912	14	1.714	2.300
CLEANERS	902	6	1.333	2.550
CUTTING OPERAT.	612	14	2.000	1.262
GAS STATION	623	18	2.000	1.101
LABORER-CONSTR.	751	36	2.727	.055
FREIGHT HANDL.	753	22	2.333	1.874
ASSEMBL.-MFG.	348	5	1.200	N.A.
CARWASH	764	4	2.000	.289
FORGEMAN	404	5	3.000	-.671
CASHIER	310	3	M.V.	1.412
			II. LOW STRAIN GROUP	(HIGH DECISION LATITUDE, LOW JOB DEMAND)
PHOTOGRAPHER	191	3	N.A.	-2.524
ADVERTIZ.	192	5	1.500	-1.791
THERAPIST	076	5	N.A.	- .773
NAT. SCIENTIST	054	18	0.714	-1.325
DENTIST	062	6	2.000	-1.848
PROGRAMMER	005	18	0.000	- .846
MGR.-EMPL. AGRI.	826	17	0.200	-2.290
TOOL DIE	561	10	1.333	.510
ENG. CIVIL	011	10	0.000	.992
ELECT. LINEMAN	433	7	2.000	-2.984
FORESTER	025	4	2.000	-1.026
POPULATION MEAN			1.59	0.000
σ			.61	2.801

associations with psychological strain (see Karasek, 1979a; Broadbent and Garth, 1981; Goiten and Seashore, 1980; and Gardell, 1979): low decision latitude and psychological job stressors, (here the z-scored sum of workload and job insecurity). If our hypotheses are confirmed, a visually obvious pattern of associations should be discernible in the diagram. Indeed, a rather clear pattern of association does emerge: occupations with low decision latitude and high stressors have high psychological strain, and those with high decision latitude and low stressors have the lowest psychological strain. Table 9 lists scores for occupations in the furthest extremes of the plot. The far extreme occupations vary by approximately two standard deviations on the psychological composite score. Given the size of the occupation groups (n's up to 20), the likelihood that the occupations at the extremes of the plots really have the same psychological strain is highly improbable.[47] It is also noteworthy that the results are consistant with individual level asociations between job and psychological strain reported above.

The occupation-based estimates of job characteristics also confirm an association between coronary heart disease and job characteristics. For these analyses, the data bases with heart disease information contained no directly

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[47]The R^2 for a multivariate regression equation based on occupational-level job decision latitude and psychological job stressors is 28%, a rather strong degree of association for a psychological strain scale to have with objective job characteristics (and physical demands, Table 9, further differentiates occupational psychological strain). It must be admitted, however, that most of the variance in the psychological strain composite is not captured by a between-occupation scale: of the total individual-level scale variance (roughly 25% is scale unreliability) only 10% of the variance occurs between occupations. It is also interesting to note that in a multivariate occupation level regression analysis, a single multiplicative interaction term which captures the joint effects of the job decision latitude and the composite job stressor scale, has an R^2 of 0.28 (with an additional increment to R^2 of 0.05, contributed by low physical exertion). Interaction term = 1.0 (combined stressors) / 1.0 (decision latitude) - with the two variables standarized to each have a variance of one with means of +1.0 and -1.0 for combined stressors and decision latitude, respectively. This is a parsimoniously formulated interaction where strain is at a low level in the situation of low demands and high control.

Table 10

Selected Occupations in Four Job Risk Categories

Occupation	Census #	(N) QES	(N) Hanes	QES Physical Demands	QES Composite Psych Strain
				III. ACTIVE GROUP	
ENG. ELECTRICAL	012	12	21	0.500	- .343
COUNSELOR	174	4	4	0.000	- .375
SALES MGR.	233	13	20	M.V.	-1.100
MGR.-SELF AGRI.	825	41	20	2.190	- .256
BARBER	935	10	11	2.300	.357
OFFICIAL	223	7	7	M.V.	.413
ARTIST	194	10	8	1.250	.321
MGR. UTIL.	829	4	11	M.V.	- .608
LAWYER	031	6	20	M.V.	- .234
				IV. PASSIVE GROUP	
WATCHMAN	962	19	24	1.000	- .696
POLISHER	621	11	9	2.000	.964
COUNT.-CLERK	314	3	3	M.V.	.845
CLERK-BILLING	305	8	8	0.750	2.032
CLERK-POSTAL	361	14	16	1.200	- .123
SAILOR	701	4	0	N.A.	N.A.
CLERK-STOCK	381	22	15	0.833	.125
SECYS.-MFG. MALE	836	9	0	N.A.	N.A.
JANITOR	903	34	60	2.300	1.024
BUS DRIVER	703	7	21	0.500	-2.014
OPERS.-MINES	603	23	11	1.750	1.066
MAIL WORKERS	332	17	23	2.111	.937
OPERS.-AG/DUR	852	7	4	1.500	.331
LABORERS-SERV.	861	21	21	M.V.	.536
FORK LIFT OP.	706	15	11	0.000	- .620
OPER.-ELEC/TRAN.	854	2	8	2.500	N.A.
POPULATION MEAN				1.59	0.000

NOTE: * = AGE CORRECTED

measured job characteristics, but only the respondent's occupation and industry. Using job characteristic scores estimated from the QES surveys (ANCOVA MODEL - adjusted for demographic covariance), statistically significant associations are observed between clinically assessed coronary heart disease prevalence and the same job characteristics which predicted psychological strain above. In the U.S. Health and Nutrition Examination Survey 1971-74, low decision latitude, psychological work load and low physical exertion are all significantly associated, after controlling for age, with CHD (see Karasek, Theorell, Schwartz, Pieper, and Michela 1983). The same methodology of estimating job characteristic information for national occupation codes was also applied to Swedish data bases, both as a source of job estimates and heart disease data, and yielded consistent results. Using Swedish Central Statistical Bureau data on analogous job characteristics, the combination of hectic job, rushed tempo, and repetitive low control work was significantly associated with the incidence of myocardial infarction in a Stockholm case control survey (see Alfredsson et al, 1982 for further discussion). Both of these job characteristic/CHD findings, based on estimated job characteristics, confirm associations between job characteristics and CHD using directly measured, individual level data (Karasek et al 1981).

DISCUSSION

In summary, our occupational scoring system is designed to provide an empirical methodology for assessing the impact of job circumstance when only limited job data is available. The theoretical goal of our system is to provide a set of alternative causal linkages between work and well-being to the conventional social status measures which for the most part, are anchored in a purely economic conception of occupational causality. Our scoring system appears to work well for some job characteristics (task control, some physical and psychological stressors), and imperfectly, though still usefully for others (other psychological stressors). Hopefully some of the weaker dimensions can be supplemented in the future by data from other surveys, or from partial individual level data on the target data bases. The system

appears to generate unbiased estimates of job characteristic associations, and allow estimates of the extent of lost statistical power over individual level data.

What conclusions can be drawn from the various findings obtained using our method? Because our system appears to estimate in an unbiased manner (albeit with weaker statistical power) the associations of job characteristics with various indicators of health and since our scores are corrected for demographic factors (including social class) that would otherwise lead to spurious associations, we judge that positive findings resulting from our method are likely to be indicative of true associations at the individual level - probably of substantially greater strength than we observe. Borderline associations may indicate either stronger true associations, or simply statistical irregularities, but the coefficients of association for multiple job dimensions should allow easy selection of specific occupations relevant for additional study. An absence of association between an estimated job characteristic and an outcome measure presents an interpretive problem, since the between-occupation variance of our dimensions is generally less than 50% of the total variance. It is impossible to rule out the possibility that true associations between job characteristics and illness do exist, but remain unobserved because they are related only to within-occupation variation in job circumstance. On the other hand, it would require a sophisticated rationale to account for such a phenomenon.

Significantly, our system does appear to succeed in predicting psychological stress, depression and cardiovascular illness in a manner consistent with research based on directly measured, individual level data. In these fields of research, occupationally based estimates of job characteristics have the further advantage of being less subject to the criticism that any associations found between job variables and psychophysiological illness was an "artifact" of self-report bias in job situation measures (see Karasek et al, American Journal of Public Health, 1981). Much stronger associations between job and psychosocial health are observed using our system than by using conventional status measures. Our

findings strongly suggest that the unidimensionality of the conventional scales leads to strong masking effects and overlooks multivariate assoiation (some of which are almost mutually orthogonal).

The obvious primary shortcoming of our system is that it overlooks substantial variations in job circumstance within occupations. This omission has lead some researchers, notably Kohn[48] to recommend against occupational estimates, lest their "cheap price" lure researchers into a false sense of security about predictive specificity that could come from analyses based on occupation title only (albeit at a very fine grain of detail). We agree that replacement of research based on direct individual measures with occupationally-based estimates would be a serious mistake. Instead, we feel the best strategy would be a hybrid of both approaches. A major shortcoming of individual level analyses is that scarcity of resources necessarily limits their scope to a single factory or a single community, and such studies often also omit reference scales that could facilitate comparison of the specific site to national mean scores. This omission substantially limits the generalizability of small studies and inhibits integrating their findings into broader understandings. We feel individual level instruments could be developed which include questions from national surveys as reference points, not only for correlating site specific dimensions to broadly defined national job characteristic scales, but also to serve as a reference standard for judging whether a small site is "high" or "low" in relation to national "standard" scores. Indeed, our research group has tried to develop an instrument for measurement at the individual level which would be consistent with our national sample-derived scores.[49] Finally, the greatest advantage of systems such as ours is that it allows estimation of job characteristic associations that would otherwise require vast resources to discover - by use

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[48]Personal communication, August 1980

[49]Such individual instruments (based on our national scales) are being used in studies by Piotrokowski (1982) and Gordon (1982).

of only job title, industry and demographic information about the individual. While analyses based on occupational estimates alone might be incomplete, such systems should allow "targeting" occupations that are highest or lowest on suspected job characteristic "risk factors" for further detailed analyses at the individual level. Indeed a strategy for more effectively "targeting" research resources may be an essential first stage to many research efforts given the increasing scarcity of funding.

IV. ASSOCIATIONS BETWEEN JOB CHARACTERISTICS AND CARDIOVASCULAR ILLNESS

A. THE HEALTH STATUS DATA BASE: US HANES 1971 - 1974

We can now use the job characteristics scores estimated in the previous chapter to test hypotheses about job-related stress and CHD (from Chapter II). The primary problem to be faced in occupational epidemiological studies is availability of data. Normally, almost all data bases with precise clinical information on CHD would be unavailable for analysis becuase of lack of simultaneous job data. Our job scoring inference system dramatically reduces this restriction, of course, allowing us to test any data base with job title (or Census codes) plus information of rough industry, self employment and conventional demographic information. We have decided to first apply the system to often utilized and respected clinical CHD survey conducted by the U.S. Public Health Service and National Center for Health Statistics: the U.S. Health and Nutrition Studies of 1971 - 1974. This data base is used as the basis for many national statistics on the prevalence and demographic breakdown of CHD and related diseases in the U.S. today.

1. Sampling Procedures

The "detailed component" of the Health and Nutrition Examination Survey (HANES), conducted between 1971 and 1974, is representative of non-institutionalized persons in the United States (6,913 subjects were examined, age boundary: 25-74). The HANES design is complicated by the fact that it had an additional examination component - a nutrition survey. Because of the nutrition survey low-income and elderly groups were oversampled since they were believed to be most affected by malnutrition. Thus, our analyses are based on findings weighted for proportional representation of the U.S. population for the HANES. The final analyses are made on the males in the sample, age 25 and over, and with occupation data, (approximately 17% of the males over age 20 are missing occupation data). In addition, our analyses are made with the white males only for final sample sizes of 2190 on the HANES.

Figure 12A: MODEL OF JOB-RELATED PSYCHOLOGICAL STRAIN

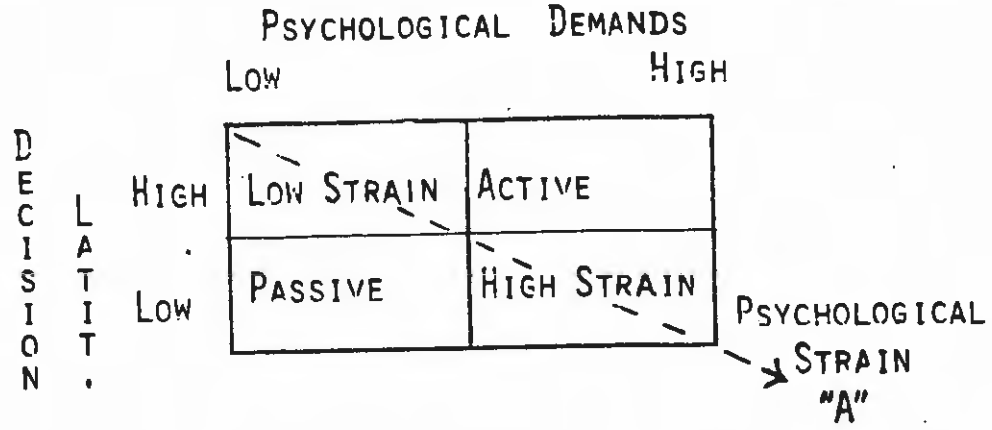
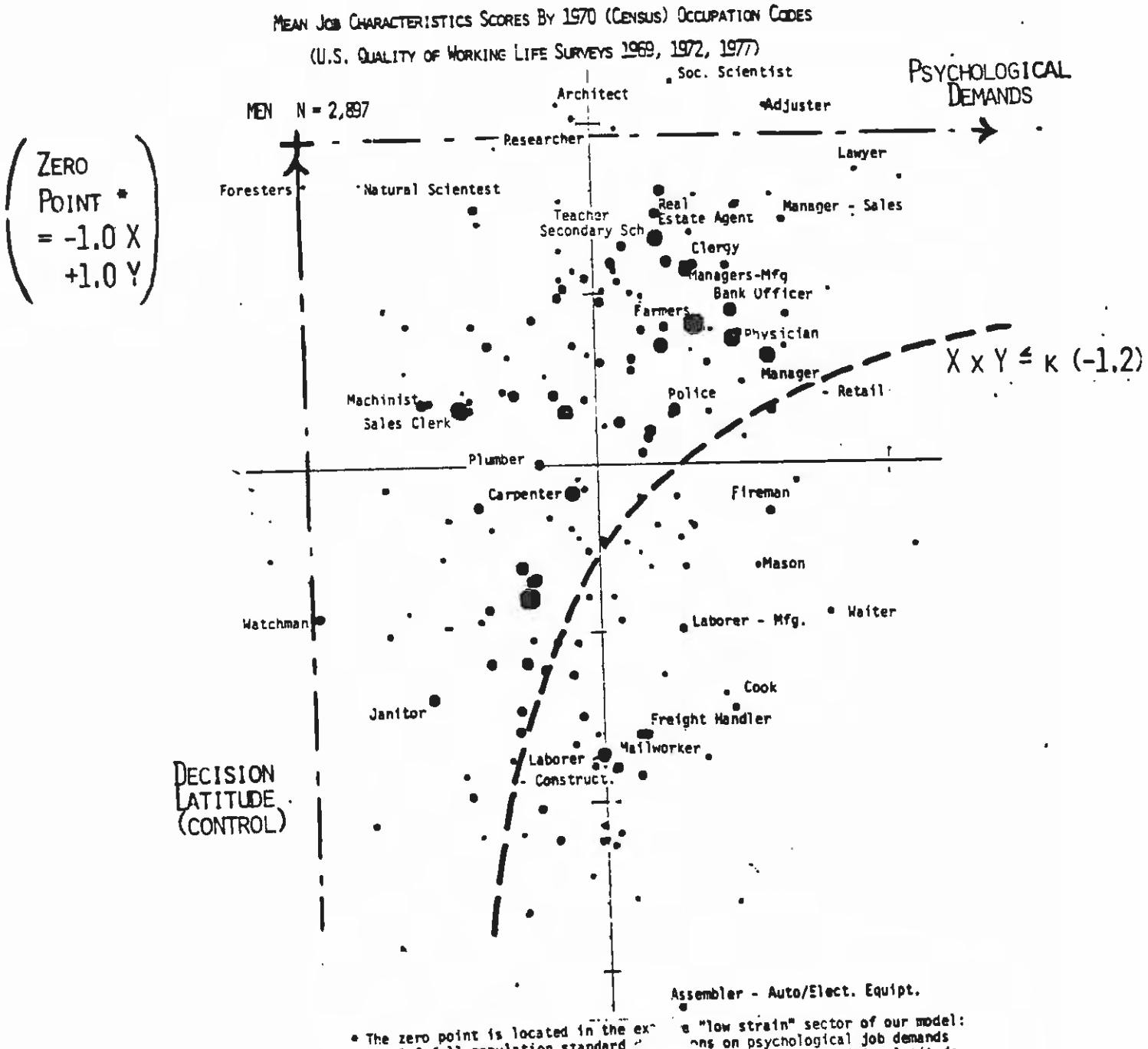


Figure 12B: DEFINING A HIGH JOB-STRAIN SUBPOPULATION



* The zero point is located in the ex[illegible] "low strain" sector of our model: at -1.0 full population standard [illegible]ons on psychological job demands and at +1.0 full p[illegible]tion standard deviation units on decision latitude.

2. Examination and Data Collection Procedures

In this study, all subjects were examined in mobile units utilizing standardized protocols. A self-administered questionaire was given to each subject to answer. If necessary, assistance was provided by a receptionist. The examining physician then asked additional questions prior to carrying out a physical examination. During the physical examination, blood pressure was measured three times on the left arm with the examinee in a sitting position. There were only minor variations in the way blood pressure was recorded between the two surveys. Following the physical examination, blood was drawn by venous puncture. Chest X-rays, EKG, and other laboratory procedures were performed. Smoking in the HANES data base was measured by the question: "On the average, how many cigarettes do you smoke per day?" For the HANES 1971-1974, the final four doctor panel verdict CHD coding has still not been completed. The presently available HANES data for CHD is based on the diagnosis from the field examining physician's review of the medical history, the detailed cardiovascular questionaire, the complete physical examination, and included access to chest X-Ray, and EKG tracking. However, the doctors did not know the final analysis of the 12-lead EKG or the chest X-ray. The available data is probably a conservative estimate of the prevalence of a past myocardial infarction in the HANES and identifcation of false positives is not judged to be a severe problem.[50]

B. ANALYTIC STRATEGY

Our basic hypothesis from Chapter II can now be formulated in more precise analytical terms: first, psychological stressors such as work load, job insecurity and possibly noise contribute additively to CHD risk. However these risk can be "moderated" by job control (decision latitude) and by social

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[50]The following comments from the HES experience supports this judgement: "80% of all cases where the examining physician recorded a diagnostic impression of definite heart disease [93% of M.I. diagnoses were definite] and 59% of all cases with a diagnostic impression of suspect heart disease were ultimately diagnosed as heart disease [by the clinical panel]."... "The physicians' diagnostic impressions lead to a substantially smaller count of heart disease than did the final survey diagnosis." (N.C.H.S. Series 11 - No.6, p. 40). Most inter-physician variability occured for angina pectoris.

support. Both of these latter factors may operate interactively as well as in linear (subtractive) fashion. Thus, non-linear formulations involving multiplicative terms may be appropriate even though much more difficult to test. Physical exertion may be protective (linealy, subtractive) for CHD risk, or at least operate in a manner quite differently, (possibly opposite) to the psychological stressors. Finally other physical stressors which could directly induce physiological damage such as toxic exposure or accident hazards are considered independent contributing risk factors (additive).

To provide a single, inital illustration of the job-CVD associations and to further test the implications of the high demands/low control interaction term, an analysis of two-by-two contingency tables is performed (controlling for age, catagorized into six deciles). A multiplicative interaction term is designed to capture the 25% of the population with simultaneously low control and high psychological job demands (condition = 1, otherwise = 0). The interaction term is defined in a parsimonious manner: it is based on an equally weighted product of z-scored decision latitiude and psychological demands, with their zero points defined in the "low strain" region (at individual-population z-scores of +1.0 for decision latitude and -1.0 for demands-see Figure 12B). The cut point of the interaction term, thus defined, which isolates at least 15% of the population (the dichotomous job strain term = 1) over age 45 in the high strain category, as well as at most, 35% of the full population, is 1.0 for the adjusted scores and 1.2 for the mean (unadjusted) scores. Physical demands (dichotomized) is included as a third independent variable in the ANOVA analyses along with "strain" and age (white males only). Statistics for the contingency tables, based on dichotomous dependent variables, are calculated according to Mantel and Haenzel (1959).

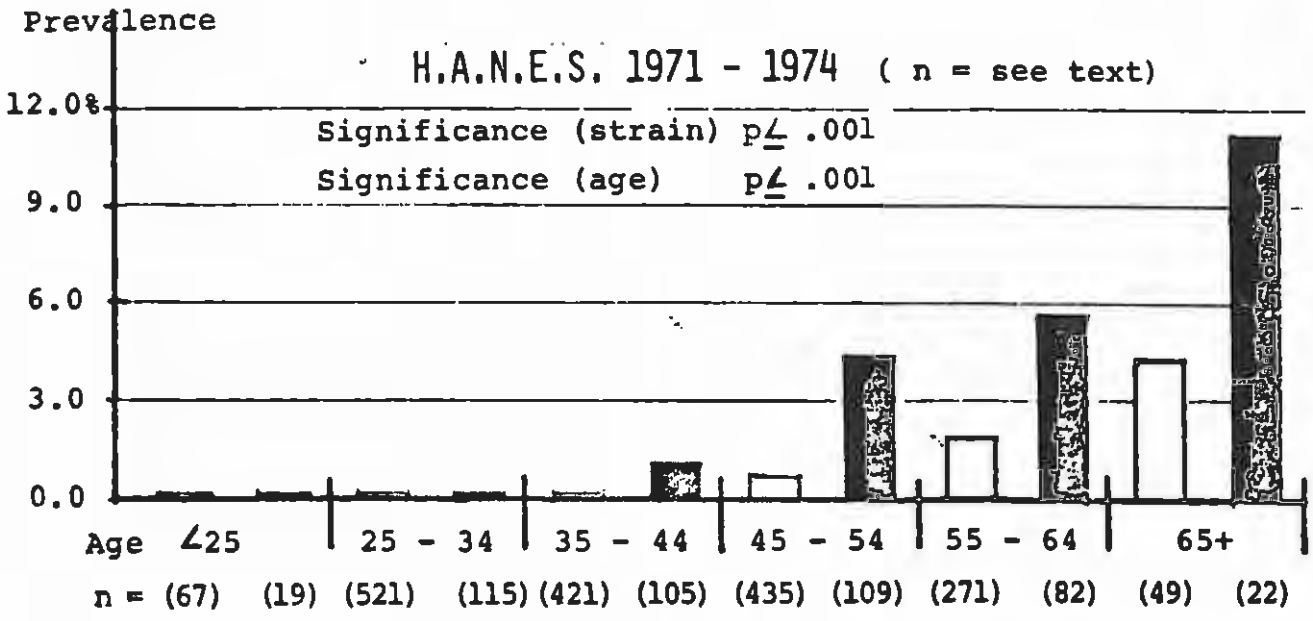
The final analysis of myocardial infarction prevalence, based again upon white employed men, utilizes a multiple logistic regression technique (Brand et al 1976) developed by Damstrom and Damstrom (1979). For systolic and diastolic blood pressure, continuous variables, ordinary least squares multiple regression techniques are used. The variables age, education, average daily cigarette smoking (HANES), serum cholesterol (HES), job decision latitude, work load, job insecurity, physical exertion on the job, and job

able 11: PREVALENCE OF A MYOCARDIAL INFARCTION BY AGE AND JOB STRAIN IN THE U.S. H.A.N.E.S.

EMPLOYED WHITE MALES

High Strain Occupations*

Other Occupations



* Calculated on the basis of mean job characteristic scores of R's occupation

noise[51] were simultaneously tested with regard to their ability to predict past myocardial infarction (the conventional risk factors are forced into the equation; the job variables are included only if p </= 0.2). In separate regressions, the uncorrected job characteristics scores are utilized (based on simple occupational means), and then the adjusted job scores are utilized (incorporating demographic variables as described above see also Appendix (VI). An interaction term based on low control and high demands (see above) is also added, in separate analyses. The standardized odds ratio (SOR) was calculated for each of the predictors. This is the change in likelihood of CHD development for each standard deviation change in the predictor.[52] Statistical estimates based on standard ordinary least squares ANOVA and regression techniques are designated (OLS).

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[51]Social support is excluded from the analyses because of its very low between-occupation variance (it does not enter significantly in the regressions).

[52]The standardized odds ratio for the logistic regression coefficent (B) of an independent variable whose standard deviation is 's' is, $SOR = e^{Bs}$. Using this, one can estimate the relative risk (odds) of an event occurring to/for those individuals who are located at the extremes of the distribution of the independent variable or "risk factor". The decile-to-decile relative risk is approximately $SOR^{3.29}$ (since the "midpoints" of the outer deciles should be about 1.645 standard deviations from the mean). "Risk factors" are often defined as variables that are associated with at least a doubling in the risk of illness. Assuming this is based on a comparison of the top and bottom deciles, a potential cause would need to have a standardized risk ratio greater than 1.235 (since $1.235^{3.29} = 2.0$) to be considered a risk factor (thus, many of our associations in Table 2 qualify). To illustrate, the association between serum cholesterol and CHD has a SOR of about 1.6 in many epidemiological studies (Brand et al, 1976). This means that its decile-to-decile relative risk is 4.69:1 - the odds of someone in the top decile of the distribution of serum cholesterol having an MI is 4.69 times as great as the odds of someone in the bottom decile. If the overall probability of an M.I. is 0.0200 (corresponding to an odds of .0204), then the probabilities of an M.I. for those within the low decile and high decile of serum cholesterol are estimated to be .0093 and .0423 (odds equal .0094 and .0442) respectively. If the overall probability of an event is low (as for CHD) and the SOR is not too extreme, then a relative odds ratio will only slightly over-estimate the ratio of probabilities.

C. RESULTS FOR HANES (HES analyses not yet complete)

1. Myocardial Infarction

The results of a simple contingency table analysis of the relationship of myocardial infarction prevalence to age and job characteristics for white males in the HANES is shown in Table 11. In the HANES a clearly elevated prevalence of M.I. is observed in the "high strain" occupations ($p \leq 0.001$ significance). In all age categories, In other analyses (not shown), physical exertion at work is added as a third factor to the ANOVA model. In the HANES, physical exertion is negatively associated with M.I. prevalence, ($p \leq 0.045$ [OLS]).

The results of a multivariate analysis simultaneously controlling for other known M.I. risk factors for the white male population are shown in Table 12. Associations are run both with simple mean scores on the job characteristics by occupations, and secondly with occupation scores which have been adjusted for the covariance of job characteristics with age, education, race, marital status, self-employment, religion, and urbanicity. This later strategy specifically controls for possibile coefficient bias which can result from inaccurate estimates of the association between job characteristics and demographic variables. As expected, age is the most important correlate of a past myocardial infarction in both data bases. Of the conventional risk factors, blood pressure is analyzed in both studies and has a consistent, but marginally significant negative association with a past myocardial infarction. Information about smoking is available in the HANES where we observe no significant association with past myocardial infarction. Education is not significantly associated with past myocardial infarction in the HANES.

Decision latitude is significantly negatively associated with the prevalence of a past myocardial infarction in the HANES; the lower the decision latitude, the higher the prevalence. The standardized risk ratio is (SOR = -1.81; $p \leq 0.001$) in the HANES. It is remarkable that the decision latitude coefficient is by far the strongest correlate, after age, of M.I. in the HANES, with an SOR higher than serum cholesterol as reported in many other

prevalence or incidence studies, (such as the Framingham or Western Collaborative Group Study). Psychological work load is significantly associated with M.I. prevalence in the HANES, (SOR = 1.85; p </= 0.022). Physical exertion showed a very significant negative association with prevalence in the HANES, (SOR = -1.85; p </= 0.002). In the HANES, using stepwise regressions (not shown), the signficance of the job decision latitude coefficient clearly increases (F statistic from 11.9 to 17.3; OLS), in the step when physical demands are included. This suggests that "protective" effects of physical demands may mask the "risk - inducing" effects of low decision latitude for low status workers.

Finally, we have tested for the possible significance of a decision-latitude/psychological demands interaction such as the one outlined in Figure 12B. However, our preliminary tests with this and other simple interaction terms are inconclusive at present. Such terms indeed appear to parsimoniously isolate a high strain group in our contingency tables, and they are significant in some regressions. However, our data base does not appear large enough to allow us to consistently and significantly differentiate clearly significant linear association observed from interaction terms, or to unambiguously determine whether the interactions add significantly to the predictive power observed for the linear formulations.

2. Blood Pressure

The results of the simple analysis of variance for systolic and diastolic blood pressures by job strain (Figure 12B) by age deciles for white males in the HANES are shown in Figures 13A. In the HANES systolic blood pressure does not show significant variation by job strain in the two youngest age cohorts up to age 35. However, at advancing age (45-65) a clearly increased elevation of systolic blood pressure occurs for individuals in high strain occupations amounting to two to seven millimeters of mercury by age 65 (in the HANES). Overall, the high strain population differs significantly, and consistently from the remainder of the population (p </=0.001 in the HANES) in systolic blood presssure. After age 65 there is a curious reversal of this relationship, and the blood pressures of the high strain group drop both absolutely and relatively below those of the rest of the population. This last finding could be anomalous for several reasons. First the employed high

Table 12: MULTIPLE LOGISTIC REGRESSION ANALYSIS* OF PREVALENCE OF MYOCARDIAL INFARCTION IN THE U.S. HANES 1971-74 NATIONAL CLINICAL SURVEYS EMPLOYED WHITE MALES

VARIABLE	HANES 1971-74 (N=2190)			
	MEAN SCORE		RECON. SCORE	
	S.R.R.	P≤	S.R.R.	P≤
AGE	4.20	.000	6.23	.000
EDUCATION	-1.09	n.s.	-1.19	n.s.
SYSTOLIC BP	-1.36	.085	-1.38	.081
CHOLESTEROL	-	-	-	-
SMOKING	1.20	n.s.	1.25	n.s.
DECISION LATITUDE	-1.71	.005	-1.81	.003
PSYCHOLOGICAL DEMANDS	1.36	.182	1.85	.022
PHYSICAL EXERTION	-1.69	.006	-1.85	.002
NOISE EXPOSURE	-	n.s.	-	n.s.

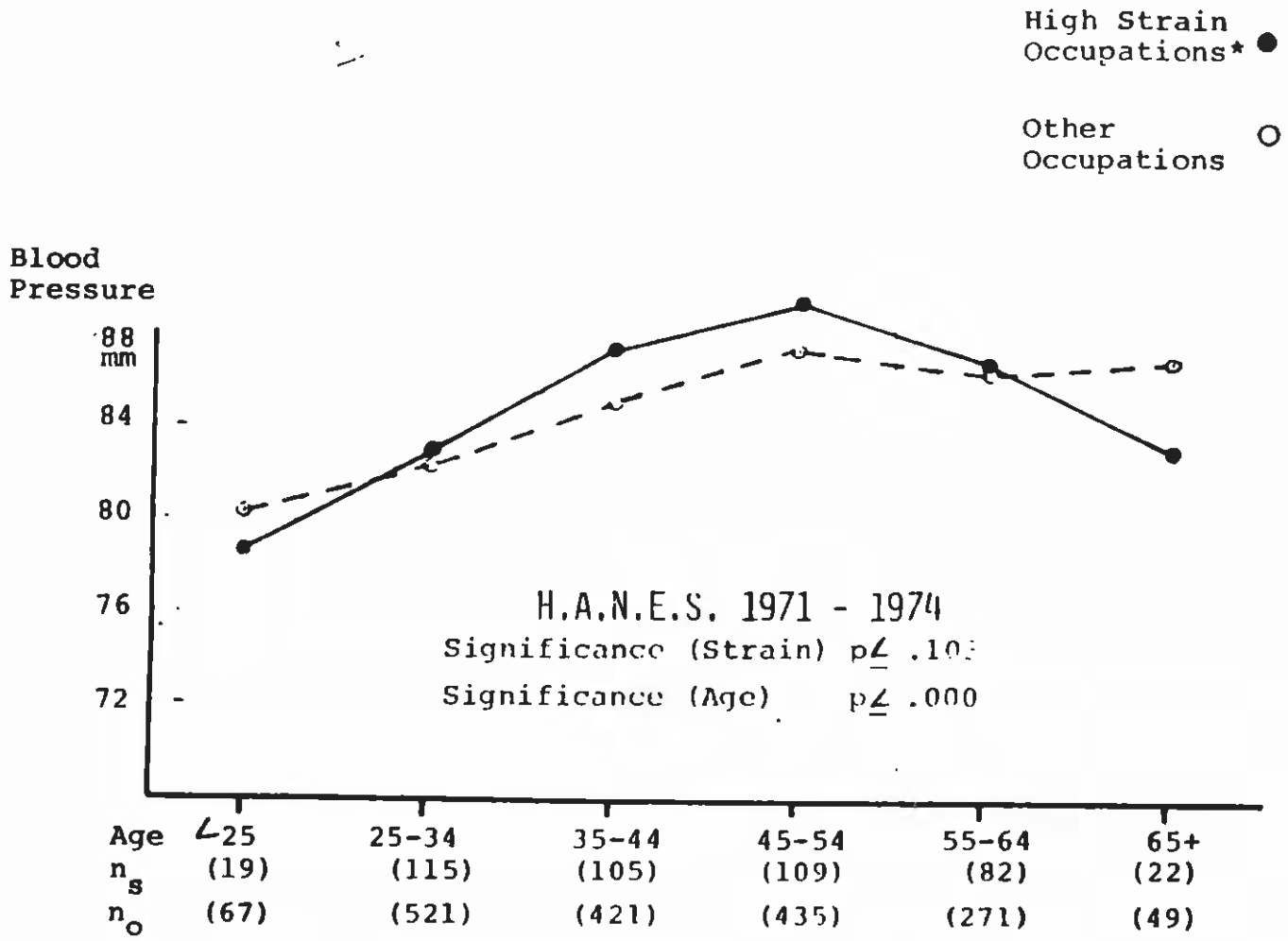
* All demographic and physiological variables forced into the equation ("n.s." - implies $p \geq 0.20$); job variables eliminated from equation if $p \geq 0.20$

strain subpopulation still working after age 65 is very small (n = 22 in the HANES). Also after the retireent age of 65 working is a much more personally voluntary activity, and self-selection factors are thus likely to be more salient (yielding very healthy sub groups). Most significant, however, is the possibility that blood pressures have dropped for the high strain group because of past myocardial infarctions (the previous section showed myocardial infarctions to be over twice as common in this group as in the remainder of the population). Further analysis, selecting out individuals with past M.I.'s, could test the validity of this suspicion, and we expect to perform such analyses in the near future.

The gradually increasing relative elevation of blood pressure for the high strain group with advancing age is also consistently observable for diastolic blood pressure, particularly between ages 35 and 65 (of approximately three millimeters at age 55). However, the signifance of the elevated blood pressure pattern is only borderline (p </= 0.10 in the HANES). For diastolic blood pressure in the youngest age cohort, the high strain occupations actually have lower pressures. As with systolic blood pressure after age 65 the high job strain group show declining blood pressures, again possibly because of blood pressure drops after myocardial infarction, or strong selection factors present in the over age 65 working population.

Table 13B displays the results of multivariate regression analyses for systolic and diastolic blood pressures. Clearly, the strongest association are for age, for both blood pressures. Education does not show a consistent effect, although it is significantly negative for systolic blood pressure in the HANES. Smoking is significantly negatively associated with both systolic and diastolic blood pressure in the HANES. Among the job variables in these regresssion analyses, psychological job demands are most consistently associated with high blood pressure, especially diastolic blood pressure, (p </= n.s./.05 in the HANES). Decision latitude does not show the same strongly significant negative associations that are observed for myocardial infarctions with diastolic blood pressure, but consistent negative associations are observed for systolic blood pressure. In summary we do find elevated blood pressures for high strain jobs but the pattern differs for systolic and diastolic blood pressures. Diastolic blood pressure appears to be more

Figure 13 MEAN DIASTOLIC BLOOD PRESSURE BY AGE AND JOB STRAIN IN THE U.S. H.A.N.E.S.



*Calculated on the basis of mean job characteristic score of R's occupati

attributable to high psychological work load, while systolic blood pressure is attributable to low job decision latitude. However further analyses will have to take greater account of selection and medication factor before these conclusions can be given much weight. Most important, this analysis will remain incomplete until controlled for the presence of M.I., which may be responsible for the curious reversal in strain associations at age 65.

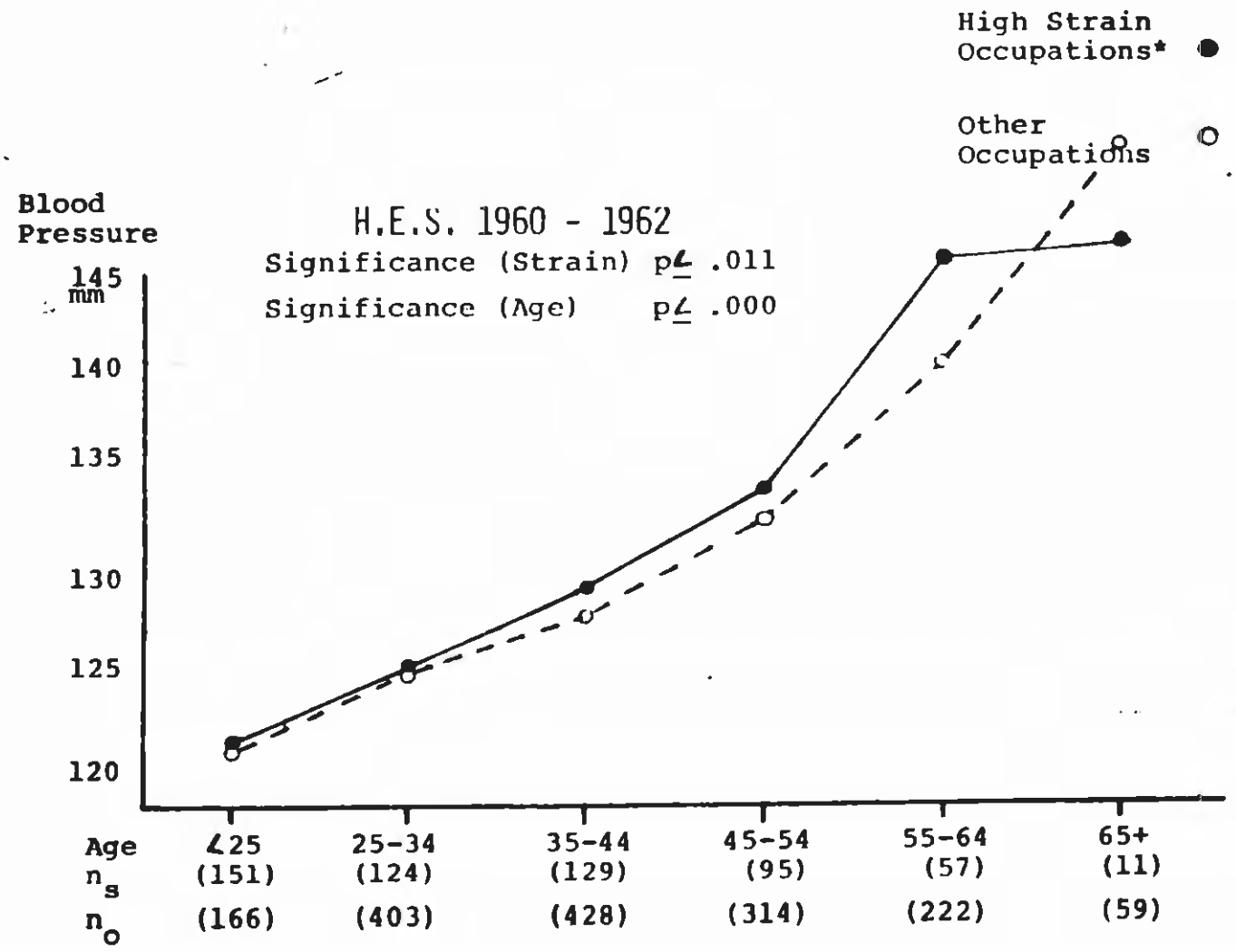
V. DISCUSSION OF CARDIOVASCULAR FINDINGS

Our findings are generally consistent with other studies in terms of most standard risk factor associations with M.I.: age, cholesterol, smoking, and even systolic blood pressure, (see p.87) and also reveal expected associations with job characteristics. While at the broadest level job related strains are associated both with increased blood pressures and myocardial infarction, detailed examination of job characteristics reveals a different pattern of risk factors. The negative associations observed for decision latitude and M.I. are weaker for blood pressure, and multicolinearities with low education are also observed here. Psychological job demands are a more obvious correlate of high blood pressure (particularly diastolic) than of myocardial infarctions. Finally, these blood pressure analyses are still preliminary, and await final corrections for individuals with past myocardial infarction.

Although education has been demonstrated to be negatively associated with the risk of myocardial infarction in several studies (Hinkle et al 1968, Leren 1980; Marmot, 1978;), it is not significant in our analyses of the HANES. Our methodology differs signficantly from the above studies however, since job characteristics (which are somewhat colinear with education) are included simultaneously in the multivariate logistic regressions. The result is that job characteristics are substantially more significant than education, even though education is measured much more exactly and at the individual level than job variables (consistent with Swedish findings also, {Karasek et al, 1981}). It appears that the previously observed effect of education is mediated through the type of job one enters. If job situation is the pathway by which education has its impact on health, it is not surprising that job characteristics, (even approximately estimated) absorb the variance due to this status measure.

In our introduction we noted increasing evidence of low status elevation in CHD prevalence in spite of lower risk on conventional risk factors (and protective factors). Has our detailed examination of job characteristics unveiled any low status "aggravating factors" that could account for the higher than expected prevalence of M.I. among low status groups? Indeed, such evidence is found. Two characteristics of low status work with potential

Figure 14 MEAN SYSTOLIC BLOOD PRESSURE BY AGE AND JOB STRAIN IN THE U.S. H.A.N.E.S.



importance in stress physiology emerge: low job decision latitude appears to be a strong CHD risk factor, while physical exertion appears to be protective. Physical exertion's protective effects have been studied before, but rarely has low job control been studied as a risk factor. For some low status workers the protective effects of beneficial kinds of physical exertion might "mask" destructive effects of low job decision latitude. If workers are examined in only very aggregated status groups, these job effects may cancel out.[53] Indeed, aggregated measures of social status - education, income, Duncan scale - are precisely the measures which have been used in past studies to justify the claim that occupation's effects on CHD are minor or ambiguous.

Low decision latitude on the job was strongly and significantly associated with past M.I. on the HANES with simultaneous controls for age, systolic blood pressure, smoking (HANES), and education (with sex and race held constant), despite the relatively small number of cases observed among employed white males in the HANES, (prevalence rates of 1.3%). Low decision latitude in combination with high demands also isolated a group with significantly higher M.I. prevalence in almost all age categories using contingency table analysis. This "high strain" working population is the same group identified with high psychological strain in related studies, (see Figure 11). These findings are consistent with effects of low decision and job autonomy on increased incidence of coronary, or cerebrovascular mortality in working Swedish males, (Karasek et al, 1981). They are also consistent

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[53]Strong evidence for such a conclusion comes from analyses carried out to predict psychological strain within the QES surveys. Three job characteristics- decision latitude, psychological job demands, and physical exertion (using unadjusted occupation based scores)-predict 33% of the variance in a psychological strain composite measure; while the Duncan socio-economic index predicts only 6.9%. Simultaneously our three job characteristics predict 73% of the variance in the Duncan scale (income and education, together the defining variables of the scale, predict only 74%). The important issue is that psychological strain is predicted by a <u>different combination</u> of these three variables than that which is associated with Duncan social status. In particular, decision latitude is <u>positively</u> correlated with status, but strongly <u>negative</u> in its assocciations with psychological strain. Thus, conventional social status measures provide a very poor summary of the effects of occupation on health. Specific measures of job circumstance reveal far stronger associations.

with the findings of Alfredsson et al, (1982), that low job control (over pacing and skill variety) particularly in combination with hectic work load and being under age 55, is predictive of elevated myocardial infarction risk in Stockholm.

Our findings for psychological job stressors cannot be said to be strongly supportive of the significant body of literature identifying psychological work load, per se, as a risk factor for CHD, (such as Hinkle et al 1968; Theorell and Floderus-Myrhed, 1977, and Buell and Breslow 1960). Psychological work load enters the regressions weakly, (significant on the HANES), and job insecurity is not significant at all. Indeed, exposure to noise enters one equation contrary to hypothesis. However, these psychological stressor variables have relatively little of their variance between occupations (Table I), implying that our methodology is less efficient at estimating job scores for these variables. Thus our irregular or non-supportive findings could be due to the weakness of the occupational inference technique for these variables.

The fact that the job characteristics were not reported by the subjects themselves, but are estimated for occupational groups, makes this study different from other studies published in this field - with both advantages and disadvantages. The fact that average scores of job charcteristics for each occupation were used, makes it possible to generalize beyond the level of the individual's own perception of his job situation. It could not be argued, for example, that our findings are due only to the fact that individual subjects with poor coping mechanisms perceive their decision latitude as low and therefore develop more myocardial infarctions. Individual subjects who under-report or exaggerate psychosocial problems in their jobs will be more correctly classified with regard to job characteristics in the present study than in studies based on individual reports. The lack of self report bias in occupation based scores is a decisive advantage in a study of psychosocial risk factors given the criticism leveled at other studies of such risk factors (see Mausner and Bahn's {1974} critique of Russek and Zohman 1958, although that criticism emphasized the even greater impact of bias on retrospective estimates of events). However, our method has the disadvantage of probably underestimating the associations between the job characteristics and

myocardial infarction, (for a discussion of the estimated "true" association see Schwartz and Pieper, 1981, also see Alfredsson, 1983). This is due to the inevitable loss of predictive power that occurs when only the between occupation variation in job characteristics can be used for prediction. Two bakers may differ on "decision latitude": one rolling artistic croissants in a French pastry shop; the other working in a mass production bread loaf bakery. This variation in decision latitude is lost in our analysis. This loss of variance is more substantial for the psychological stressor dimensions, (psychological work load, job insecurity, and noise), than for decision latitude and physical exertion (see Table 1). The loss of variance is somewhat improved when the demographically adjusted scores are used (Schwartz and Pieper, 1981). However the primary advantage of the adjustment process is that it produces unbiased coefficients (Schwartz, Karasek and Pieper, 1982 (also see Chapter III) in the case when both demographic factors and job characteristics are used as exogenous variables. It avoids bias in the associations with M.I. which would diminish the job characteristic coefficients and inflate demographic coefficients, due to the direct individual measurements of the later and the estimated versions of the former.

The cross-sectional nature of the study should be born in mind. Although both prevalence and incidence associatons have been valuable in establishing causes of illness, (Epstein, 1967), some risk factor associations may diminish, once a severe disease becomes overt. This leads to lower prevalence associations: smokers tend to quit smoking (athough prevalence and incidence associations are similar for smoking in Swedish studies) blood pressure often decreases after a myocardial infarction. This may explain the weakly negative association of myocardial infarction prevalence and blood pressure, and the insignificant association with smoking in the present study.[54] Cholesterol, on the other hand, usually shows the same associations with myocardial infarction in prevalence studies as it does in incidence studies, (Epstein 1967), which we also find in our study. Physical activity may also decrease as a

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[54]Our prevalence associations for blood pressure and smoking are quite similar for example to prevalence associations in Framingham psychosocial factors analysis (Haynes, 1978; Table 6,7)

consequence of a myocardial infarction. This may explain part of the negative association between physical demand and prevalence of myocardial infarcton in our prevalence study. However, our findings are also consistent with incidence findings (Paffenbarger and Hale, 1975) that physical activity on the job may be protective with regard to risk of myocardial infarction. This matter is by no means resolved, in light of the finding that a combination of psychosocial work load and frequent lifting or static effort may increase CHD risk, as found for concrete workers, (Theorell and Floderus-Myrhed 1977). Only a few studies have addressed the question of differential prevalence and incidence associations for psychosocial factors. The available evidence indicates that Type A behavior shows the same association with myocardial infarction regardless of whether incidence or prevalence is studied (Haynes, 1978; Haynes et al, 1980; Rosenman et al 1964, 1975). In a Swedish study of cardiovascular symptoms, the associations between psychosocial job characteristics (intellectual discretion, job demands, and personal schedule freedom) and symptoms were the same prospectively as they were in prevalence, Karasek et al, (1981). The expected change brought on by a myocardial infarction would again be to reduce the job strain risk factor (probably by reducing demands, since increasing job decision latitude is not usually an employees option). Thus, there is no reason to believe that the psychological strain associations found in this study would overestimate associations for such variables in a prospective study.

Prevalence studies are particularly vulnerable to the possibility of risk factor "selection" as a source of the observed associations. Our findings above must be assessed from the perspective that myocardial infarction prone subjects might "select into" the high strain categories. One variant of the selection hypothesis would argue that men with a low educational level have no other alternative to increase their income than to choose "high strain" jobs. However a detailed analysis of income levels among Swedish workers in all the quadrants of the job stress model presented in Figure 1A, (Karasek, 1976) showed that there were only minor differences in income levels between the "high strain" categories and several other categories (the "passive" job quadrant and about half of the "low strain" quadrant). Alternatively, job ambitions might be the goal of subjects with the coronary prone Type A behavior (Rosenman, et al, 1964), who could be more prevalent in the "high

strain" category - rendering the association between "high strain" and myocardial infarction at least partially spurious. However, most studies of the prevalence of Type A behavior have shown that Type A behavior is more frequent in higher status social groups (see Kornitzer, 1981), and is thus unlikely to explain our main association. It is perhaps worth observing, again, that it is not in high status managerial or professional occupations (where Type A or high incomes may be most prevalent) that we record the highest level of CHD. Instead, the peak indicence occurs in a subset of lower status jobs with high psychological "work load" and low job decision latitude. (Assemblers, inspectors, cutting operatives, stock workers, waiters and cooks would appear to qualify by job characteristics, but our numbers do not allow specific occupations to be identified.)

Recent studies involving similar job/CHD hypotheses, but based on incidence data, cast doubts on "selection" as the sole source of such associations. Karasek et al (1981) found that incidence of CHD in previously symptom free patients was similar to the prevalence pattern. Also, associations appeared even stronger in a subsample with no job change over a six year period then they were in the full sample, suggesting that subjects selected <u>out</u> of high strain jobs. Analyses of psychological strain symptoms in the Quality of Employment Surveys, using the same methodology, (Schwartz, Karasek and Pieper, 1982; Karasek, Schwartz and Pieper, 1982 {see Chapter III}), clearly reveals a high prevalence of psychological strain in what we have labeled the "high strain" occupations. Physiologically "weaker" individuals would not be likely to "select" jobs with such clear signals of distress, and indeed those remaining in such jobs in our cross-section are likely to represent a non-vulnerable group.

Details of the possible causative pathophysiological chain of events between job characteristics and M.I. remain to be fully elaborated, (see our earlier discussion in Chapter I, see also Raab, 1970; Eliot, 1974; and Karasek, Russell and Theorell, 1982 for a general discussion). However, physiological mechanisms do exist which could account for the increased incidences of CHD found in various occupational groups. Early findings of Selye (1958) showed increased production of catecholamines in acutely stressful and cortisol in prolonged stressful conditions in animals which

predisposes the myocardial tissue to non-ischemic infarction. Additionally, he found that cortisol particularly sensitized the myocardium to the effects of catecholamines. Several field studies have found catecholamine elevations occuring in high strain occupations, (Frankenhaeuser and Johansson 1974; Timio et al, 1977). Cortisol has also been found to be elevated in high strain conditions (Timio et al, 1977; Rissler and Elgerot, 1978). Several authors have speculated that catecholamine and/or cortisol stress levels may have importance both in the atherosclerotic process and in the triggering of myocardial infarction resulting in sudden death, (Raab 1970; Traxler et al, 1977; Lown et al, 1977). This balance may be shifted towards pathologic states under conditions of chronic stress, (Engel and Schmale, 1972). Decreased blood clot lysis has also been reported in conditions of high, chronic stress (Mustard and Packham, 1969; Haft and Arkel, 1976) which may also serve as a contributing factor to cardiovascular disease. Blood pressure elevations may also reflect this imbalance. Indeed, blood pressure findings of this study, reported in detail elsewhere, (see Ahlbom, Karasek and Theorell, 1980), parallel those of CHD with respect to the job characteristics which elevate risk.

Are job related causes of CHD simply a "cost" that must be paid for a prosperous industrialized society? The multiple dimensions of our interactive risk model argue against that contention. It does not seem to be the demands of work alone (or even primarily) that are associated with this stress-related illness pattern, but rather the structure of work organization. Greater control over the work process particulary at low job levels (Karasek 1979a) would appear to be crucial. This would argue against extreme forms of the division of labor (mental and physical work) where some workers have excessively routinized jobs and no control over work processes; some jobs have no physical exertion, but much mental strain; and still other jobs lead to total physical exhaustion.[55] The search for an indirect solution to these problems, e.g. jogging by sedentary white collar workers, does not appear to

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[55]While our findings suggest the potential desirability of some physical exertion, physical stressors in the form of exposure to toxic agents and hazards obviously represent separate issues entirely.

be a promising approach for dealing with the threats of low job control. For low status workers, turning to other spheres of action in search of autonomy and self-realization does not appear to be an effective or available strategy (Karasek 1976, 1978c, Meissner 1971). Surprisingly, however, the needed changes in work organization may be economically profitable, instead of costly or ineffective. "Revolutionary" changes in work structure, departing from the highly specialized tasks of a hierarchical organizational structure, and involving worker decision participation, have been advocated for the last two decades by "Quality of Working Life" researchers, "socio-technical job designers, and more recently - even management consultants advocating Japanese or Western European management styles (for discussions see Davis and Cherns, 1975; Glasser, 1975; and Ouchi, 1981). In the U.S. most of these changes have been advanced in the name of "productivity improvement", through enhanced worker morale and reduced resistance to technological changes. The direct well being of workers has hardly been the driving force for such developments in most U.S. experiments, although such purposes are clearly behind similar European initiatives. The possibility that these very changes in job design also reduce the risk of job related CHD would be an even stronger reason for advocating change - one with even more direct positive effects on the lives of the working population in society, and an issue which could directly involve unions and other employee organizations. Undoubtedly, much more research will be needed to confirm the special nature of work-related CHD risk factors. If confirming evidence accumulates, the risk reducing interventions may shift interest in psychosomatic illness from individually oriented "life style" cures or patient treatment to structural changes in work organization. The developments above suggest that this course of action may be as "practical" as it is socially equitable.

VI. SUMMARY OF THE REPORT

The core of our work is an attempt to assess the association between job characteristics and coronary heart disease using date available in currently existing health surveys and registries. Using data from Sweden, our group has demonstrated associations between low control on the job, as well as high psychological work loads, and the prospective development of cardiovascular mortality and morbidity (Karasek et al, 1981). The primary problem with continuing such research particularly in the United States is the lack of detailed job characteristic data on clinical surveys of CHD. To overcome this data deficit we have developed the occupational inference method for estimating job characteristics from job title, which has been funded by our N.I.O.S.H. Grant for use in U.S. analyses of job/CHD association.

A. RELIABILITY OF THE OCCUPATIONAL SCORING SYSTEM

The goal of the occupational scoring system for job characteristics is to be able to reliably estimate job characteristics of an individual worker where no direct information on individual job characteristics has been gathered, but where job title or detailed occupation codes are avaliable. Our occupational scoring methodology develops a set of job characteristics for each U.S. Census three-digit occupation code. These scores measure job decision latitude (authority and skill utilization), psychological stressors (work load, hours, job insecurity), social relations at work; and physical stressors (physical exertion, noise exposure, temperature exposure, hazardous condition exposure). The scores are also adjusted for the influence of demographic factors such as age, race, education, marital status, self-employment, region and urbainty using covariance analysis. We use a national sample of approximately 4,500 males and females gathered in the U.S. Department of Labor Quality of Employment surveys in 1969, 1972, and 1977, to develop job score estimates. These estimated scores can be assigned through job title (coded into the U.S. census codes) on the target health status data base.

We have analyzed score reliability of our scoring system in four ways: standard errors for each job's characteristics have been computed for each occupation (so "reliable" occupations can be differentiated from "unreliable" occupations); external comparisons are made with other job characteristic

scoring systems; internal scale reliability and cross-sample occupational score reliabilities are computed; and finally we have compared job characteristic/health associations predicted by our occupation based, estimated job scores with the associations derived from the original individual level data for psychological strain to assess the success of our system in capturing the underlying associations in a data base.

1. The basic statistical strength of the inference occupational scoring system depends on the amount of variance in job characteristic scores that occurs between occupations of the U.S. census codes. Within-occupation variations will be lost when occupational mean scores are generated (the difference in objective job characteristics between two bakers, one in French pastry shop and the other in a Wonder Bread factory, is lost in our system). This lost variance simply attests to the fact that no occupation-based scoring system can ever be as accurate as the individually measured job characteristics. In the tables (Chapter III), we indicate how much of the reliable job characteristic variance occurs between occupations (after correction for demographic factors). We list the cross-sample reliability of occupation scores based on three separate survey years (a three-part, "split-half" reliability). This measure estimates the replicability of the scores, i.e., the likelihood that other samples will yield similar job scores for each occupation. We also list the internal scale reliability of each of the scales (this measure is less important in our methodology than in analyses with individual-level data, since only the reliable variance differs systematically between occupations). In general, the cross-survey reliabilities are quite high, attesting to the replicability of the occupation scores across surveys. The internal scale reliabilities, however, could be improved in several cases (notably job insecurity).

2. We have correlated our job characteristic scores, where possible, with the U.S. Dictionary of Occupational Titles scores (consolidated into Census codes by Spenner 1981 and Temme 1975). For decision latitude, the correlations are .77, .75, and .51 for three comparable D.O.T. scores and, for physical hazards and physical exertion, the correlations are .60 and .62. We consider this to be good agreement in light of the entirely independent methodologies and even differing scale content between our scores and the D.O.T. scores.

3. Finally, we compare the job characteristic/illness estimates using our occupation scoring system to estimates derived from the individual level data. Using the Q.E.S. as a source of both job characteristics and psychological strain data (a University of Michigan depression scale), we find that the prediction R^2 drops to roughly one-third of the value obtained using individual-level data when we use the occupation scoring system estimated scores. However, the regression coefficients and their relative statistical

significance were replicated very well by our system (Schwartz and Pieper 1981). This analysis also provides evidence that the procedure for adjusting the job scores for demographic covariance (age, education, etc.) does indeed reduce this potential source of bias. Furthermore, we could quite accurately estimated the strength of true individual level associations, using only the occupational-scoring methodology and our estimates of measurement unreliability.

In summary, our occupation scoring system works well for some job characteristics (decision latitude, some physical stressors), and imperfectly, but still usefully, for others (some psychological stressors). Hopefully some of the weaker dimensions can be supplemented in the future by data from other surveys, or from partial individual level data on the target health surveys (the Western Collaborabice Group Study data, for example, does include individual level data on psychological work load). Our system appears to generate unbiased estimates of job characterisitc associations, and allows estimates of the extent of lost statistical power over individual level data. Significantly, the system does appear to predict psycholoogical stress and cardiovascular illness in a manner consistent with other research. Finally, the system's great advantage is that it allows estimation of job characteristic associations, that otherwise require vast research resources to discover, by use of only job title, industry, and demographic information about the individual.

B. FINDINGS TO DATE ON THE ASSOCIATIONS BETWEEN JOB CHARACTERISTICS AND CHD USING THE OCCUPATIONAL INFERENCE METHOD

Our research with the occupational title system has resulted in the demonstration of job characteristic/CHD findings consistent with findings based on individual level data from Swedish record. Our U.S. clinical data is drawn from the primary sources of CHD prevalence data in the U.S.; specially the 1960-62 Health Examination Survey of the U.S. Public Health Service, and the 1971-74 Health and Nutrition Examination Survey [HES results not yet available]. Using multivariate logistic regression techniques and controlling for age, education, blood pressure, smoking and cholesterol, we have found in the U.S. HANES 1971-74 data set significant negative associations between decision latitude and CHD prevalence, significant negative associations

between physical exertion and CHD, and significant positive associations between psychological work load and CHD. An interaction term isolating a 25% subpopulation which has similtaneously low decision latitude and high psychological work load is significantly associated with CHD prevalence using contingency table analysis (controlling for age). It is noteworthy that an attempt to duplicate our methodology with Swedish data on job characteristics and CHD has also led to consistent results. Individuals with work which is simultaneously hectic and repetitive are at significantly greater risk for M.I. (a case control study with 338 M.I. subjects in the Stockholm area).

The consistent pattern of job-related risk for low decision latitude and high psychological work load (and, occassionally, low physical exertion) is also demonstrated for blood pressures in preliminary analyses. Relative elevation for both systolic and diastolic blood pressures for the "high job strain" is zero or negative at young ages and rises to between 2 and 7 mm of mercury by age 55 (at age 65 a curious reversal occurs, but our findings have not yet been controlled for the presence of M.I. which would reduce blood pressure). Overall the M.I. and blood pressure findings are consistent with a new model of stress-related cardiovascular illness presented in this report based on a review of physiological and psychological literature.

The same job characteristics associated with myocardial infarction are associated with a composite measure of psychological strain (depression, sleeping problems, physiological stress symptoms, job dissatisfaction), yielding a preliminary (but not yet rigorously tested) inference that psychological stress is an intermediate step on a pathway between job characteristics and heart disease. Using psychological stress as a dependent variable has helped us understand why conventionally used status/class indicators, such as the Duncan Socio-Economic Index, have lead to ambiguous conclusions in the literature as to the association between occupation and stress-related illness. Use of more detailed measures of job experience, such as ours, reveals substantially stronger associations than the conventional status scale approach. Our conclusion is that unidimensional indicators, such as the Duncan scale, fail to capture all the relevant variance in job characteristics (because of omitted orthogonal associations and masking effect). Thus when job characteristics are entered into multivariate analyses

with education, the job experience variables capture most of the variance (leaving education barely significant). Another finding in our studies is that if any "selection" mechanisms are influencing our results, the effects are likely to understate rather than overstate associations between job and illness because selection out of high risk occupation appears to be more frequent than selection into them.

In general, our present state of wisdom might be summarized as follows: Preliminary evidence exists, based on Swedish incidence and prevalence data and U.S. prevalence data, to suspect significant associations between some aspects of job structure--most notably low control over decision possibilities--and coronary heart disease (indeed the association are as strong as those observed between CHD and smoking or serum cholesterol). Furthermore, the associations appear sufficiently robust that they can be detected by the relatively "weak" estimation techniques represented by our occupational title methodology. The immediate research agenda would appear to include further analyses of major U.S. data bases to confirm associations with CHD incidence; analyses with women's data; and attempts to test physiological "risk factors" (blood pressure, ECG) as easier-to-measure intermediate variables on the pathway between job and CHD. The occupation-based scoring system also lends itself well to targeting of high and low risk occupations. This should expedite field studies to collect the direct data on jobs and cardiovascular physiology that is needed for final evidence of an association. Our results to date are indeed consistent but they cannot yet be said to be definitive. They suggest a clear and attainable future research strategy. Furthermore, our approach appears to yield one research tool to begin to open the door to epidemiological analyses of occupation's social and psycholocal risk factors.

APPENDIX I

PHYSIOLOGY OF STRESS AND REGENERATION IN JOB-RELATED CARDIOVASCULAR ILLNESS

Although numerous studies have been published on the relationship between job stress and cardiovascular disease, few studies have examined the possible environmental correlates of processes of growth and regeneration. The aim of this appendix is to review physiological and psychological aspects of such processes as they relate to cardiovascular disease that may potentially be linked to work environmental characteristics, within the context of stress physiology.

In the following sections we will attempt to organize relevant research findings into a comprehensive hypothesis of environmentaly mediated physiological regeneration and strain, particularly in relation to cardiovascular illness. Our two dimensional job strain hypothesis (Chapter II) predicts substantial environmental stressors to be associated with pathology only under certian environmental conditions. Under other circumstances the same levels of environmental stressors may be conducive to growth and regeneration, by which we mean development of the organism's adaptability to increased levels of environmental challenge. The determinant environmental contingincy is the degree of control the individual has in coping with the stressor: stress accompanied by low control leads to strain, whereas stress accompanied by high control leads to regeneration.

The phenomenon of growth that often occurs in situations of environmental challenge illustrates that a high stress level is not necessarily harmful. Some very clear examples come to mind. Children's muscular development occurs in situations clearly "stressful" where the individual is challenged to run faster or jump higher than he or she had been previously able to do. As in the current popular sport of jogging, the individual is facing an increased stressor but is totally self-paced and in control of the response to demands (in comparison to assembly line workers facing a speed-up).

Growth analogies are available in psychosocial behavior. Karasek (1979a) has hypothesized that psychological learning is promoted in situations where high levels of environmental challenge are matched by high control possibilities. Incremental additions to competency (i.e., learning) are hypothesized to occur most often when the challenges in the situation are matched by the individual's control over alternatives or skill in dealing with those challanges, (see also Csikszentmihalyi, (1975)). Under these circumstances opportunities for constructive reinforcement of nacent behavior patterns are optimal: the situation will not be unchallengingly simple [thus, unimportant (White 1959)] nor so demanding (Stauffacher 1937 and Courts 1939) that appropriate corrective actions can neither be determined nor invoked. That later situation will simply result in psychological "strain" discussed above. Congruency between this theory and social learning theory is described elsewhere by Karasek (1979b). Work environmet evidence exists for development of active behavior patterns and related psychological orientations when stressor and control possibilities are both high (Karasek 1976, Benninghaus 1981, Goiten and Seashore 1980, Karasek 1981b, Karasek, Lindell and Gardell 1982, Karasek 1978c). Psychological strain phenomena occur in situations where stressors and control are in disequilibrium, (see Chapter II).

In general it will be noted that the literature in the area of "regeneration", is scarce, and thus our hypotheses are speculative in this area. However, the importance of this activity is attested to the shear volume of cell regeneration which is observed. The cells in several bodily systems have a short life expectancy. Polymorphonuclear leucocytes, which are essential in the defense against infections, for instance, have a life span of eight days. Cells of the mucosal lining of the digestive system which are essential in the defense against ulcer development have a life span of two to five days, and red blood cells which transport oxygen in the blood, circulate for an average of 120 days (Bloom and Fawcett, 1975). We will first discuss strain-related and regenerative mechanisms with respect to endocrine and metabolic processes, in terms of catabolism and anabolism. Then we examine cardiovascular functioning, where these two mechanisms are labeled "arousal" and "regeneration" respectively.

A. PHYSIOLOGICAL MECHANISMS OF STRAIN AND REGENERATION: ENDOCRINE AND METABOLIC PROCESSES

1. Catabolic Responses (Strain):

When the organism is responding actively to a challenge, the blood provides the muscles and the brain with fuel in the form of glucose and lipids. Glucose is mobilized from glycogen deposits (glycogenolysis) and lipids from fat deposits (lipolysis) (Guyton 1981). That these changes take place during acute arousal has been documented in several studies, (Cannon 1914, Nazar et al 1976). If the challenge is intense, proteins are broken down into glucose and other products (gluconeogenesis) (Guyton 1981). All these processes which use available deposits in order to provide fuel are labeled catabolic. Catabolic responses are mediated by several hormone systems, which along with anabolic processses, are influenced by the central nervous system (Bovard 1962). The most extensively studied catabolic processess are the catacholamines and cortisol (Tepperman 1976, Yates, Marsh and Maran 1980). Catecholamines activate in early stages of arousal to a stressor. Cortisol may be more important in later stages and is more associated with feelings of disstress and depression, (Starkman et al 1981, Bosman and Kazemier 1979, Carroll 1976, Bourne, Rose and Mason 1968). The blood levels of glucose and triglycerides (lipids) rises (Carlson, Levi and Oro 1972) and the breakdown of the nucleic acids into uric acid increases during acute arousal (Rahe, Ryman and Biersner 1976, Rubin et al 1955).

The metabolic consequences of longlasting arousal have been less extensively studied. Animal experiments by Henry et. al. (Henry et al 1971, Henry and Stevens 1977), have demonstrated that mice exposed to chronic ecological stress develop increasing levels of enzymes responsible for the synthesis of catecholamines. Thus, longstanding arousal may cause chronic excess production of catecholamines. Chronic excess plasma catecholamine levels have been correlated with hypertension (DeChamplain 1977, and a predisposition to myocardial ischemia (Selye 1958, Rabb 1970a, Januszewicz and Sznajderman 1972, Bassett et al 1978). They have also been suggestively

linked to the progression and development of atherosclerosis (Carruthers 1969), with a possible direct toxic effect on the intimal lining of the vessels, (Fleckenstein and Rona 1975, Haft 1974, Kones 1975).

It is important to distinguish between effects of chronic levels of arousal or "stress" and more temporary "subacute" arousal. For instance, life-long psychosocial cumulative strain may have significance to hypertension and coronary atherosclerosis whereas "subacute" arousal such as periods of intense psychosocial work load (Theorell and Floderus-Myrehed 1977), or bereavement (Parkes et al 1969) may precipitate episodes of myocardial infarction. A related distinction has to be made between reversible pathophysiological processes and irreversible ones taking place in the cardiovascular system. Depletion of magnesium and potassium from cells is a reversible change. According to Selye (Selys 1958, 1961), Bajusz (1965) and Raab (1970b), such depletion in the myocardium may, however, increase the likelihood of tissue hypoxia leading to necrosis formation in the heart even in the absence of coronary atherosclerosis, i.e. non-occlusive myocardial infarction. Irreversible changes are coronary atherosclerosis and late stages of hypertension. Changes in the synthesis of catecholamines (hypertension, Hofman et al 1979) and changes in the lipoprotein patterns (atherosclerosis, Gordon et al 1977, Rosenman and Friedman 1958) may be of particular importance in the development of chronic heart diease. However, even short term, "reversible" endocrine changes may stimulate "irreversible" consequences in the cardiovascular system. There is increased coagulability of the blood during arousal (Gertler and White 1976, Bruhn et al 1969, Cannon and Mendenhall 1914,), partly as a consequence of the actions of adrenaline and noradrenaline, (Mustard and Packham 1969, Ardlie et al 1966). This may protect the body against extensive blood loss in anticipation of physical violence but unfortunately may also stimulate atherosclerosis and has been hypothesized to lead to thrombosis in animal studies (Haft and Fani 1973).

2. Anabolic Response (Regeneration):

Because of limited cell lifetimes, repairing or anabolism becomes necessary in the survival process. If this does not keep pace with catabolism, increased vulnerability to ulcer development (Ader 1971, Brooks 1979), skin disease (Engels and Whittkower 1980), infections (Gorizontoz et al 1980, Stein et al 1979, Soloman et al 1974), and cardiovascular disease (Cairncross and Bassett 1975, Lipowski 1980) may arise.

Typical anabolic hormones are insulin (Cahill 1971, Fritz 1972) and testosterone (Tepperman 1976). Growth hormone mostly has anabolic functions, facilitating cellular amino acid incorporation for protein synthesis, particularly in skeletal muscle, as well as essential roles in long bone growth and the maintenance and adaptibility of normal renal function. Growth hormone also has catabolic functions, stimulating lipolysis and the release of free fatty acids in hypoglycemia (Manchester 1972a). Its regenerative role is illustrated by the fact that its higest excretion takes place during deepest sleep (Daughaday 1971).

These hormones interact in a complex way with those hormones which serve mainly catabolic functions. For instance, growth hormone responses to acute challenges may be blocked by elevated cortisol levels (which may have been induced by chronic arousal) in the blood (Green et al 1970, Feldman and Brown 1976, Yalow et al 1969). An illustration of this may be the findings of Friedman et. al. (Friedman et al 1971), who studied men who were exposed to an injection of amino acids normally inducing increased levels of growth hormone. Those who showed the most extreme "Type A" behavoir pattern did not respond in this way. However, after some days of rest they did respond in the normal way. Rose et. al. (Rose et al 1969) found plasma testosterone levels decrease during maximal, perhaps overwhelming challenge, which might also produce considerable anxiety (recruits starting basic training and special forces personnel anticipating imminent combat in Vietnam). They are elevated, however, in subjects who behave agressively or report agressiveness (Rose et al 1975, Persky et al 1971, Olweus et al 1980). This may indicate a relationship between active, agressive behavior and testosterone production.

Testosterone's long term responses to psychosocial stress have not been studied to our knowledge.

Anabolic hormones are esential to the regenerative process. They usually function independently of catabolic hormones (Yalow et al 1969), often directly counteracting their effects. Some examples of this opposition include protein metabolism (Tata 1970, Manchester 1972b), lipid metabolism (Fain et al 1965, Topping and Mayes 1972), glucose metabolism (Williams and Porte 1974, Ensinck and Williams 1974), and electrolyte balance (Leaf and Liddle 1974). More specifically, testosterone and growth hormone have been demonstrated to favorably influence the protein synthesis of the myocardium itself (Hjalmarson et al 1969, Williams-Ashman 1979). It should be pointed out however, that excessive amounts of testosterone have been discussed as a possible atherosclerosis promoting factor (Furman and Howard 1957, Russ et al 1955) and growth hormone in excessive amounts may also promote atherosclerosis (Brown and Goldstein 1980). Thus, anabolic hormones are important in the regenerative processes but may be harmful in excesssive amounts. Anabolic processes hypothetically occur frequently in conjunction with environmental situations which are "challenging", that is, involving high levels of stressors where the individual controls the response strategy. Increased plasma and urinary epinepherine levels in man have been correlated with arousal to emotional stimuli (Ax 1953, Funkenstein 1955, Ekkers 1975, Euler 1964), and also increased concentration and sensory involvement, (Frankenhaeuser 1980, Frankenhaeuser and Johansson 1976). It is important to note that the time course over which increased plasma epinephrine responses take place may determine whether their effects can be considered regenerative or catabolic. The temporal pattern of indivdual catecholamine responses to stress have been found to differ. Frankenhaeuser's "economic" epinephrine response (Frankhaeuser 1980), characterized by a quick return to baseline levels following short term stresor exposure, may be considered regenerative. ("Economic" response patterns appear to be faclitated by vacations, {Johansson 1976a}). A slow return to baseline represets an undesirable "overreaction" which mobilizes resources no longer demanded, (considered catabolic), and in addition contributes to chronic elevations in catecholamine levels which may

result in pathology. Contrary to its general catabolic effects in lipid and carbohydrate metabolism, Shamoon et. al. (1979) found increased plasma epinepherine levels have a protein sparing effect. Hypoaminoacidemia was induced in individuals following an injection of epinepherine, which was insulin independent and prevented by [beta] B-blocking drugs. This suggests that situations which produce arousal may selectively protect muscle tissue, including the myocardium, while mobilizing other bodily reserves for energy production. Theorell et. al. (1978) in their study of men who were exposed to a psychiatric interview, reported similar findings as Friedman et. al. (Friedman et al 1971) relating growth hormone response to stressors. In this study, the acute growth hormone elevation was seen as a "healthy" response to a psychiatric interview, whereas subjects with chronic conflicts and long term difficulties did not respond. These additional chronic stressors possibly increased the overall burden of stress to such a degree that the situation is one of serious strain.

Of particular importance to atherosclerosis is the recent observation that the high density lipoprotein (HDL) cholesterol has a protective role with regard to arterial plaque formation. It has been proposed that lipid deposits are removed from the inner arterial walls by an increased plasma ratio of high density to low density lipoprotein cholesterol (Brown and Goldstein 1976). This may prevent the early stages of atherosclerosis (Miller et al 1977). High density lipoprotein cholesterol may be seen as a typical regenerative factor. Its relation to endocrine factors, however, is largely unknown, although the female sex hormone may raise HDL serum levels (Gresham 1979, Furman and Howard 1957, Russ et al 1955).

Regular physical activity causes long term elevation of the blood levels of high density lipoprotein cholesterol (Paffenbarger and Hyde 1980, Hartung et al 1980). In addition to raising serum HDL and lowering serum triglyceride levels (Martin et al 1977), physical exercise also improves overall glucose utilization and metabolism in the body, including circulating monocytes which are primarily involved in defense against bacterial infections (Koivisto et al 1979, Soman et al 1979). This facilitates cellular metabolism and anabolic

processes in skeletal muscle and other tissues. Regenerative effects of physical exercise have recently been found to include the reversal of some hormonal and metabolic effects of mental stress, (Graveling 1980). These could be seen as further examples of regenerative activities which take place during non-restful conditions.

Another area of regeneration, and possible anabolic response, concerns central nervous system (CNS) function. Specifically the interrelationship between rapid eye movement (REM) stage sleep and waking behavior.[56]

B. AROUSAL (STRAIN) AND REGENERATION IN THE CARDIOVASCULAR SYSTEM

As pointed out by several authors (Sheperd and Vanhoutte 1979, Engel and Schmale 1972, Korner 1971, Cannon 1929), cardiovascular regulation takes place as a delicate balance between sympathoadrenomedullary (SAM) and parasympathetic (PS) systems. In the absence of organic lesions in the cardiovascular system, arousal or strain is seen mainly as excessive activity of the SAM system. Regeneration corresponds broadly to the PS system. Thus, increasing heart rate may be due to stimulation of the SAM system, or to inhibition of the PS system. Conversely, the decreasing heart rate and blood pressure observed during relaxation may be due to inhibition of the SAM system or stimulation of the PS system.[57] Thus, the dichotomy between arousal and regeneration is difficult to detect through field measurements of

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[56]Becker-Carus and Heyden (1979) have shown increased REM stage sleep time is positively correlated wth active learning during waking, and negatively correlated with stress. Glaubman et. al., (1978) in a study involving individuals selectively deprived of either REM or non-REM stage sleep, found a significant depreciation in responses correlated with divergent thinking in subjects deprived of REM, compared with non-REM sleep. Together these studies suggest an important role for REM sleep in support of waking behavor, and further support the claim that REM sleep, and CNS activities occurring during these peroids enhance the individual's adapatation to new situations.

[57]Our focus on cardiac pathology tends to understate the independent, autonomically regulated contribution of the vasculature in determining overall cardiovascular function.

cardiovascular activity alone using conventional methodologies. Techniques must be employed which differentiate between PS and SAM activity (Weiss 1980, Obrist et al 1979), or otherwise more quantitatively measure the outcome of their long range effects such as metabolic, and possibly anabolic changes in the myocardium (Chance et al 1980). Physical exercise has also been found to augment the fibrinolytic response to venous occlusion in adults (Williams et al 1980).

The association between arousal and increased heat rate as well as between relaxation and decreased heart rate have extensive documentation (Astrand 1977, Benson et al 1974, Schwartz 1977). Certain rhythm disturbances in the heart, such as ventricular premature beats, may also occur during arousal (Orth-Gomer 1979). Blood pressure generally rises during arousal and decreases during rest (see Astrand 1977, Benson et al 1974, Schwartz 1977). Interestingly, regular physical exercise (Blumenthal et al 1980) as well as daily relaxation exercise (Agras et al 1980, Bali 1979, Patel et al 1981, Twentyman et al 1979, Seer 1979), can lower the baseline levels of heart rate and blood pressure, and possibly increase tolerance to stress (Hoffman et al 1982). This points out that regenerative activity may take place both during "active" and "relaxed" states. The associations between PS and SAM activity during these conditions are unknown.[58]

Related findings from animal studies of Unge (1973) have shown regular excercise within the animal's limits of tolerance which produces cardiac hypertrophy, results in a highly functional and orderly pattern of new capillaries supplying the myocardium. Hypertrophy caused by aortic or renal artery stenosis however, produced a poorly functioning pattern with few new vessels.

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[58]Obrist et. al. (1978), (see also Light and Obrist [1980], and McCubbin et. al. [1981]), have begun to describe the contribution of SAM activity in normal, healty cardiac functioning.

C. DISCUSSION

Evidence has been reviewed for associations between environmental behavior (particularly at work), and endocrine and metabolic activity in relation to cardiovascular functioning. A goal of this review has been to establish a conceptual framework, related to elements of existing stress models, for the analysis of regenerative processes which might interrupt or reverse the development of ischemic heart disease. These physiologic processes may be further defined as occurring independently of both catabolic, and "housekeeping type" maintenance functions of the body. They may also be considered to be triggered by a specially categorized set of environmental circumstances relating to "active" growth and development. More specifically, "regenerative" processes must occur to shift the balance in the body's milieu interior to one favoring growth and development, rather than a static equlibrium.

Direct evidence for physiologic regenerative processes occurring in high demand - high control situations exits for the following: increased serum HDL/LDL ratio, and lower average baseline serum cortisol and normal serum catecholamine responses, having a more rapid return to baseline levels following acute stressor exposure; and lower average blood pressure and heart rate. Evidence for the remaining phenomena considered as regenerative processes: increased cellular efficency of glucose utilization; increased neurologic / organismic adaptability as a function of increased REM-stage sleep; fewer rhythmic abnormalities; increased fibrinolytic capacity; and potentially lower average serum triglyceride, uric acid and potasssium levels, exists largely in the form of negative findings, (i. e. the strain situation producing catabolic responses) or as inferences from experimental data. One must conclude that, at present, while there is evidence for regenerative processes, much of its support remains fragmentary and circumstantial. Taken as a whole however, this body of evidence does provide a compelling picture of another important type or dimension of physical response. Links between these phenomena and the "Active" environmental situations (high demand - high control occupational conditions) must still be further explored. The combination of the above factors may however result in a reduced likelihood of

the development of myocardial infarction and atherosclerotic processes. The converse of these processes, in combination, (here represented by psychophysiologcal strain) has been more clearly shown to result in an increased likelihood of pathologic cardiovascular outcomes.

The authors hope the two-dimensional theory may be regarded as a vehicle helpful for conceptually linking together environment and physiological functions. In this theory both "relaxation" and "active regeneration" are designated as two situations in which the individual has a high level of control over his person-environment interations (Diagram I). In the "active" case, environmental challenges are also present. This clear division in the environmental model may be somewhat artificial as both "relaxation" and "active regeneration" are most likely required together for growth processes to occur, in some manner not yet specified by the hypotheses. An example of how this might operate is found in "active" type jobs. The individual's "control" present in an active job may allow him to space short relaxation periods at his own self-determined physiologically optimum times even if the job situatuon is one of intense overall activity and challenge. Also, the "learning" possibilities inherent in these situations may increase the level of "resources" available to the individual to meet future challenges.

Physiological predictions about regenerative processes, although tentative, could be tested by relatively minor expansions of existing laboratory or field precedures. A new situational variable, "environment control", must be added, and the definition of "stressor"" more carefully reviewed so as to differentiate it from moderating, or ameliorating environmental conditions. The new dependent variables needed represent a more complex challenge. Further work must be done to identify measurable evidence of "regenerative" activity in several physiological systems. It is additionally hoped that future research will be encouraged to be more explicit about the effects of the organism's environmental possibilities for active behavior.

APPENDIX II

TOWARDS A NEW CLASSIFICATION SYSTEM FOR THE EFFECTS OF OCCUPATION

A. SHORTCOMINGS OF EXISTING MEASURES

Systems of occupational analysis presently in favor - such as class catagories, S.E.S. scales, income, education, or Duncan scores - clearly have utility in describing an individual's position in modern society. These systems have also had some success in organizing our understanding of the correlates of occupational position in terms of "rewards" to membership in industrial society and its productive organizations. However lack of ability to more precisely predict the "life quality" that results from an individual's work experience, suggests that much more complete measurements of jobs and occupational experience are possible. The existing status scales have come to be used descriptively as ends in themselves, deflecting attention from their implicit goal of predicting final outcomes in the sphere of consumption - based on experiences within the sphere of production.[59]

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[59]Goldthorpe and Hope (1974) note that while "status" is really an intermediate variable of primary use in measuring the pathway from occupation to its real consequences ("social cultural and recreational standards and behavior"; or [from other researchers] individual physical and mental health; and individual integration in a variety of social institutions), unfortunately little research is devoted to validating the scales against these final outcomes. Instead, validation attempts are directed at refining the concept of status (Coleman, Rainwater and McClelland 1978) or in confirming the accuracy of position estimates by comparison with "established" scales. Thus, the British OPCS socioeconomic groups are validated by reference to the British Hall-Jones scale; or in the U.S. case the Duncan scores (Duncan, 1961) are designed to expand the number of occupational categories which can be scored on the basis of previous N.O.R.C. prestige data. The implication of this research direction is that by merely illustrating differences on the "status" scales themselves, one has automatically confirmed all manner of distributional implications (about rewards, power, satisfaction)- without further analysis of the true association with life quality final outcomes. (continued on next page)

In this report we attempt to develop a new set of measures for occupational experience based on detailed job characteristics and detailed occupational categories. The goal of our system is to measure job characteristics that "produce" health "output" of industrial society at the individual (or microsocial) level. Our system is designed to be supplementary to or independent of the primary existing models of the output of society's production organization based on "neo-classical" economics (Samuelson, 1947; Dorfman, Samuelson, and Solow, 1958). In such systems the primary measures of the output effectiveness of a production system are wages, prices, output level and profits. We suspect that this narrowly defined "economic" perspective is limited in its ability to predict health and social/behavioral effects of work experience and that a system based on a more detailed understanding of work place experience will provide a clearer prediction.

We further suggest that this economic model of production output may be the underlying source of two major shortcomings of conventional social status systems: their inability to predict the detailed health outputs of work (beyond level of "market basket" consumption), and their overly parsimonious unidimensionality (Spaeth, 1979). The first phenomenon, lack of attention to specific, final health outputs, may well be due to the fact that in the

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(continuation of previous footnote) It is of interest in this light that a notable attempt to expand the conception of social status beyond unidimensional scales, Lenski's research on inconsistencies between status scales (1954, 1956, 1964) required for its validation the prediction of specific final outcomes: psychological strain and political behavior. Considerable methodological debate blossomed as to whether observed associations were due to inconsistencies between multiple status dimensions or the overall average status levels (Jackson and Burke 1965; reversed by Jackson and Curtis, 1972). Blalock suggests that under-identification in the status inconsistency equations made most results indeterminant (1966). Hope (1975) counters by contending that if the status inconsistency effects amount to non-linear interactions between the dimensions, they cannot be discovered with the linear models presently used. More recently Sobel (1981) offers yet another methodology for estimating such effects. Amid the debate on methodological form there is significant evidence (Jackson 1962, Jackson and Burke 1965) that multiple dimensions of status (race, education, ethnicity) improve prediction of social strain symptoms.

neoclassical economic model each individual is "free to choose" well-being with his/her wages in whatever form he/she may desire (health, appliances, neighborhood quality). According to that perspective the only interesting question about specific outputs is why individuals' preferences for specific outputs are the way they are -- a matter of "taste" and thus beyond the scope of analysis. The second phenomenon, unidimensionality, may be the result of the assumption that the impact of the production structure for each individual's well-being operates totally through his/her wages and benefits (given consumer price levels). We would have to admit that the above generalization does not closely apply to some of the "prestige" status scales which include substantial quasi-economic (i.e. not directly market convertable) benefits such as neighborhood quality (Coleman et al 1978) or community amenity access (Warner, 1949). But evidence can be found of the substantial influence of this economic model for major occupational status systems based on income, wealth and education: the family income models[60], the

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[60]Family Income models - one version of the Neoclassical Economic perspective: Here, the importance of economic parameters is obvious, although which parameter (wages, prices, output level, profits) is considered to be the most important criterion of the effectiveness of production organization may vary with the individual's position in the social system. Ability to generate high national consumption levels is the criterion for those with a societal focus (aggregated output or GNP). Ability to generate high gross output or profits is a production system owner's criterion. Ability to generate high purchasing power (wage level relative to consumer prices) is the wage laborer's criterion. This last viewpoint is also our primary viewpoint since we search for job-determined measures of individual health.

Marxist perspective[61], and the status attainment models.[62] The limitations of systems based on the neoclassical economic models are reflected in the emerging quality-of-life and social indicators research (see discussions by Gross and Straussman, 1974; and Andrews and Withey, 1976). These approaches implicitly assume that "outcomes" of work organization occur that are not summarized by the economic parameters or determined by market choice. Some of these categories of well-being (and other work outcomes) are difficult to incorporate in the individual's wage bargain or market transactions and are therefore treated as the residual category of "externalities" by economists.[63] Some examples are:

1. Psychological health of the individual
2. Physical health of the individual

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[61]Marxist Perpective: Economic surplus from the production process, is "exploited" from the workers by owners, and it is this asymmetrical relationship which determines class position. Some intermediate categories of manager and small businessman have been analyzed by Wright (1980). The dynamics of economic exploitation is the central determinant of health for the individual and society in this model. Wright (1980) would distinguish his class categories based on "social relations" of production, from other analytic categories of occupations (such as white and blue collar) based on "technical relations" of production, i.e. relating to the technologies or skill subdivisions (Such categories may indeed be closer to our system, although this should not imply that our system carries lesser implications for political action {see Karasek 1981b, p.87}).

[62]Status Attainment perspective: In this perspective the immediate focus is on measurements of the pathways by which an individual attains positions which offer high rewards. But the economic rewards still remain the primary final criteria (Duncan scores are based on aggregate income and education, but education is also a path component).

[63]Neoclassical economists argue that given "perfect markets", wages would compensate for such extra "goods" (and "bads"), and therefore the solution to the externalities problem is to expand the market's scope. Opponents (see for example Simmel 1888; Mishan 1971; Juster, Courant and Dow 1979) argue that the economic market depends on mechanisms that cannot operate for such "goods," and therefore economic analysis is not appropriate to describe the production and distribution of those goods.

3. Motivation to work and to take active initiatives[64]
4. Social behavior patterns at the micro level (individual family)
5. Social behavior/social integration at the macro level (community society).

B. OCCUPATIONS' EFFECTS BEYOND STATUS: TOWARD A NEW SYSTEM OF JOB DIMENSIONS

What is needed is a new set of measures of individual job experience that can measure how and to what extent these aspects of health are "outputs", intended or unintended, of the production structure. Unfortunately, advocates of the quality of life and social indicator perspectives have not come as far as economists in formulating models of how outcomes are produced. Starting from this list of outcomes above and the insufficiency of purely economic measures, we discuss below five strategies for deriving an appropriate new dimensional structure for job experience: (a) review literatures for similar systems (p.28), (b) adopt one existing theoretical perspective, (c) partition parsimoniously all relevant theoretical perspectives, (d) search empirically for an internal statistical structure, (e) summarize existing empirical findings linking job characteristics and outcomes, net of occupational status.

Pursuing the last strategy first, we examine several literatures for evidence that various aspects of health are associated with particular types of job experience but can not be explained by conventional status or economic measures of the job. Such job dimensions could be hypothesized to parametrize the production process for health "outputs". Measurement of task-based

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[64] The missing mechanisms of occupational causation also may explain important aspects of the effectiveness of production organization. The implication of the human relations school of management and the present quality of working life movement is that productivity (even in economic terms such as output level, output per person-hour, turnover) cannot be accounted for by economic parameters of work design alone. The missing understanding of "labor health" in terms of motivation to work, individual health, and initiatives for innovation appears to require an understanding of the same models of psycho-social phenomena needed to explain productivity in organizations (Karasek, 1979b).

"determinants of production" means we are replacing the non-specific market mechanisms with a more deterministic series of "causal mechanisms" - tying specific job characteristics to specific health outputs. We find evidence for such effects of job characteristics in several broad thematic areas. Job characteristics commonly involved are autonomy and complexity, stressors (both physical and psychological) and social relations at work (both at the micro and organizational level):

1. Job autonomy and complexity: impact on attitudes, psychological health, and learning patterns, (see endnote i).
2. Psychological work load and its association with illness and behavior pattern changes, (see endnote ii).
3. Job insecurity and risk of illness, (see endnote iii).
4. Social integration at work and its effects on productivity and "stress" amelioration, (see endnote iv).
5. Physical exertion and health vs. physical hazard exposure and illness, (see endnote v).

We have three strategies remaining for deriving a system of job dimensions, but they pose problems.[65] We do not feel that a single, sufficently comprehensive theoretical perspective yet exists covering the

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[65]The third approach is to empirically search for an "internal structure" of job characteristics. However, we would prefer to reserve most of our empirical efforts for testing the utility of our dimensional set in predicting health outcomes (though such validations help delimit the internal structure of our dimensions as well). While an appropriate structure might be 'validated' through a factor analysis of a relevant pool of job characteristics, the problem lies in defining "relevant". The boundary condition of the factor analysis, plus the number of items included in each subarea, will markedly affect the final factor structure. The question of what is appropriate to include as relevant or how to measure each job area thoroughly begs the original theoretical question. Dodging this question altogether, we (Karasek 1976) have performed factor analysis on major grouping of job dimensions in the Swedish level of living data 1968, for example, and found factors corresponding to our theoretical dimensions: intellectual discretion, schedule autonomy, psychological task demands and two physical hazard scales.

"non-economic effects of working life". Still worse, the task of conscientiously integrating or partitioning all relevent theoretical perspectives is a vast job beyond the scope of this paper. We may, however, give some structure to a rough "inventory" of job dimensions, by listing "criteria" which we feel would be theoretical prerequisites for such a system. The system of job characteristics, related to our list of work outcomes (p.__), which results from these criteria, plus the independent effects and literature reviews is presented in Figure 1 (Model II). The job characteristics of Model II are ordered in four major categories — ordered, top to bottom, roughly in terms of the level of sophistication of willful, individual or social action involved in producing their effects:

1. Physical and psychological stressors are grouped in separate categories on the basis of the physiological pathways by which they manifest their effects. This differentiation is supported by separate scientific disciplines as well as vast literatures.

2. Control structures in organizational settings are the major links between individual behavior and organizational goals and structure. Recent research in psychological stress and behavior pattern development observes that control in relation to stressors is an important, empirically distinct mediator of the consequences of stress.

3. The dynamics of group behavior, based on mechanisms of norm development, are, as Durkheim maintained, not reducable to more primitive behavioral explanations and should thus be a separate category. These dynamics individual behavior, health and productivity, and also affect collective social phenomena.

4. The macro organizational context of work activities (the social significance, social equity, institutional power relationships, and strains) represents a set of mechanisms that include political and social phenomena not easily analyzable in terms of micro level social dynamics.

5. (Model I) Economic rewards of work are preserved as an entirely separate category, because the causal mechanisms linking work to social well-being are so different (economic market "choice" of outcomes). Such measures are very distinct from our other dimensions of work, but should certainly be included in any

complete description of the work situation.[66]

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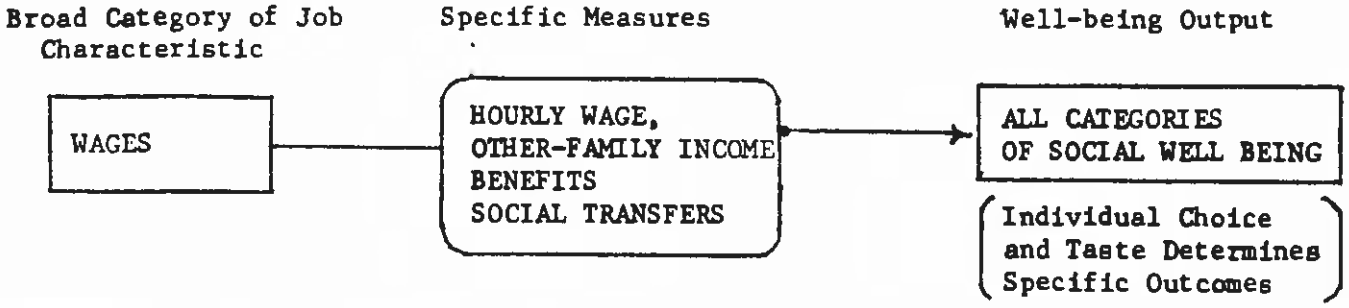
[66]While the findings below demonstrate that some "outputs" are independent of standard economic production values, it would be inappropriate to conclude that the job characteristics above are totally orthogonal to economic rewards. There is also evidence that the job characteristic dimensions are both a) related to economic parameters of work activity and may strongly affect those parameters - i.e., associations between wage, skill levels and technological change, and b) associated with position in the occupation structure (job insecurity and dual labor market theory) (see endnote vi).

FIGURE 1

JOB CHARACTERISTICS AND THE 'PRODUCTION' OF SOCIAL WELL BEING

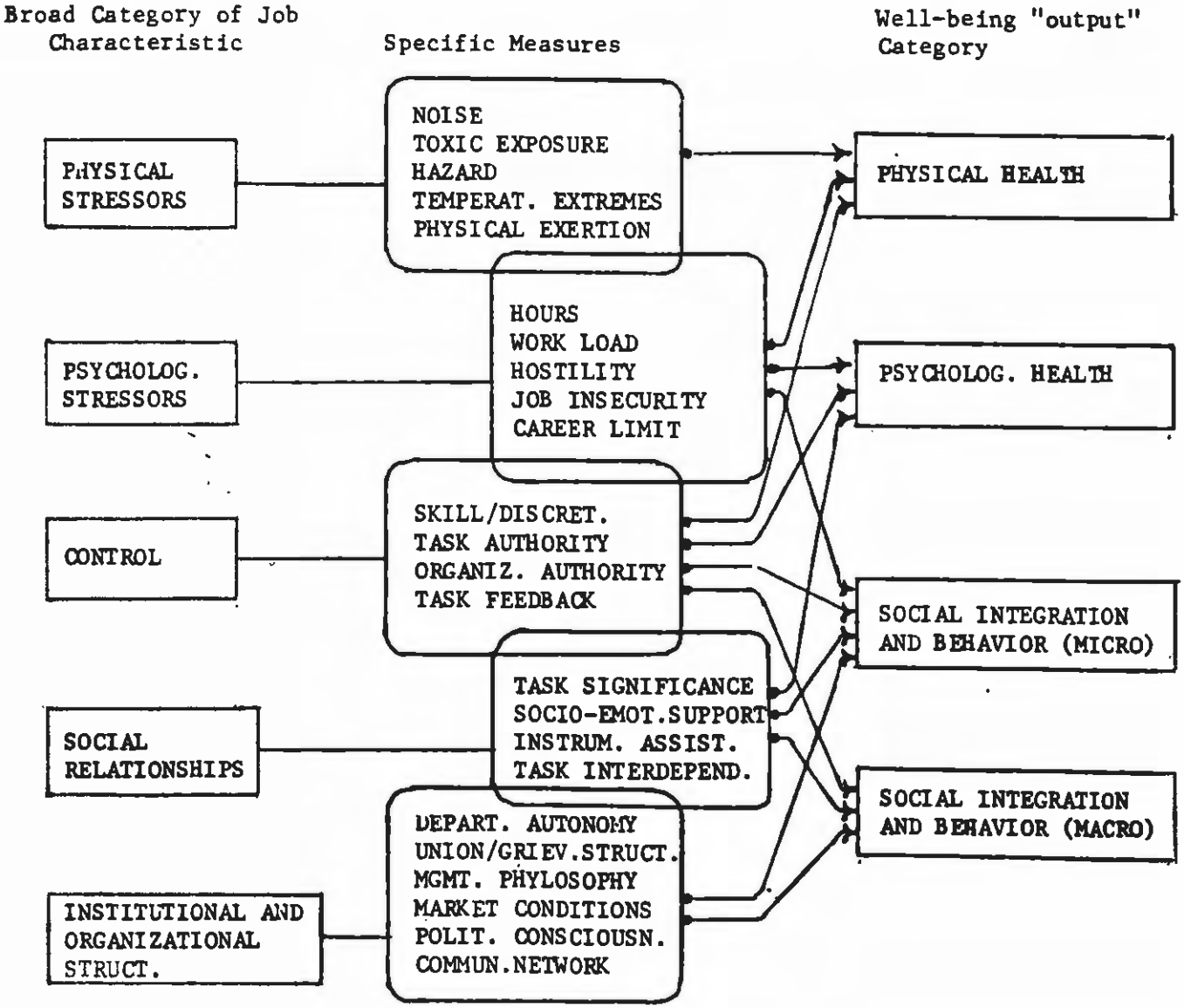
MODEL I:

SOCIAL WELL BEING (UTILITY) "PURCHASED" IN THE CONSUMER MARKET WITH WAGES



MODEL II:

SOCIAL WELL BEING 'PRODUCED' BY JOB CIRCUMSTANCE



ENDNOTES

1.

The most voluminous findings relate to job skill level and job authority. One of the broadest findings is that "occupational self-direction" (substantive complexity and intellectual flexibility) affects a variety of measures of psychological functioning, irrespective of social class (Kohn and Schooler 1973, 1978). These associations are consistent with Schliecher's (1973) and Smith's (1976) observation of a relative decline in intelligence scores for workers in long-term repetitive jobs, and Umbers' (1979) observation about the increased learning effectiveness of operators with substantial autonomy. In the area of psychological health, low decision authority and skill requirements are associated with a variety of psychological strain measures, controlling for social class (Kornhauser 1965, machine paced auto workers; Gardell 1971, lumber mill employees; Karasek 1976; Caplan et al 1975, separately for 22 occupations; Karasek, Lindell, and Gardell 1982, for white collar occupations), although associations are somewhat stronger in higher status groups (Karasek 1981a, Mulin and Blood 1968). Mortimer and Lorence (1979), in a longitudinal study, find that work autonomy also influences value systems with class held constant. Associations between low decision latitude and coronary heart disease, controlling for social class, are demonstrated by Karasek et al (1981), in a longitudinal study of Swedish workers. In the area of political participation (possibly reflecting "learning" at the community level), job decision authority and skill level are associated with political participation, controlling for social status (Elden 1981; Karasek, 1976; Karasek, Lindell and Gardell; 1982), with evidence of "socialization" in longitudinal studies (Karasek 1978b). Similar job characteristics show association with leisure behavior (Meissner, 1971; Karasek, 1976; Goiten and Seashore, 1980; Karasek, Lindell and Gardell, 1982); also in longitudinal studies, (Karasek, 1978b).

ii.

There is substantial evidence of associations between psychological stressors at work (e.g., deadlines, overall work load) and a variety of health problems. Indeed, the entire research field of "stressful life events" is based on correlations between frequencies of environmental stressors and illness (Holmes and Rahe 1967, Dohrenwend and Dohrenwend 1974). Associations are demonstrated, controlling for social class, between psychological work load and psychological strain (Caplan et al 1975 for 22 occupations; Karasek, Lindell and Gardell, 1982, for Swedish white collar workers) and between coronary heart disease and psychological demands (Theorell and Floderus-Myrhed 1977, for concrete workers; Karasek et al, 1981). Associations between job stressors and gastrointestinal problems are shown by House et al (1979) for chemical and rubber workers. Psychological work load is found associated with leisure activity and political participation, controlling for social class (in combination with task control, Karasek 1976, 1978b and also by Goiten and Seashore 1980 and Karasek, Lindell, and Gardell 1982).

iii.

The psychological stress of job insecurity has been hypothesized to be associated with illness incidence in a number of methodologies. Research using macro-level data on unemployment, but without social class control, has been undertaken by Brenner (1971), Catalano and Dooley (1977), and Eyer (1977). Although job insecurity is significantly associated with class (see Table 3), field studies have tended to hold class constant and still confirm associations with psychological health (Kerckhoff and Back 1968, Slote 1969, Kasl, Gore and Cobb 1975 - but with reservations, Cobb and Kasl, 1977). The destructive impact of unemployment on leisure and community social activities has also been well-documented (Liebow, 1967; Jahoda, Lazarsfeld and Ziesel, 1960) with class held roughly constant.

iv.

Studies by LaRocco et al (1980) and by Karasek, Lindell, and Gardell (1982) document association between social support and psychoioical strain, controlling for social class, that are both linear and interactive (moderating

stressor/strain associations). Berkman and Syme, (1979) and Marmot (1981) demonstrate associations between individuals' social networks and the incidence of coronary heart disease, controlling for social class. The impact of social integration in an occupationally-based community structure for leisure behavior patterns and political participation is demonstrated by Brown et al (1973) and Young and Willmott (1957). The broad effect of social relationships at work on behavior patterns in working class families has recently been investigated by Piotrokowski (1979).

v.

Although physical exertion and social class are significantly correlated (see Table 3), negative associations between physical exertion and heart disease are found in field studies, where class is rigorously controlled (Milvy, Forbes and Brown 1977; Paffenberger and Hale 1975 for longshoremen; and opposite findings by Theorell and Floderus-Myrhed 1977 for concrete workers). Physical stressors in the form of toxic exposures are demonstrated, in a diverse and rapidly expanding literature, to be associated with cancer morbidity and mortality incidence (for a review see Stellman and Daum, 1973). The vast majority of these studies are based on occupational groups exposed to a particular task characteristic that automatically holds class quite constant. These occupational groups include, for example, coke oven cleaners, vinyl chloride chemical process workers, pesticide mixers, and asbestos workers.

vi.

Job skill levels are associated with technological changes in the economy ("deskilling", Bright, 1958; Braverman, 1974; Dubnoff, 1978; Spenner, 1979), and with occupational mobility (Mortimer 1974, Spenner 1981, Gaertner 1976). DOT estimates of job skill requirements have been used to examine the extent of wage compensation for job complexity (Eckaus, 1964; Lucas, 1977; Scoville, 1969), with contradictory results. Job insecurity is another job characteristic closely associated with the economic rewards of work (the wage/unemployment level curve, Phillips 1958; and Marx 1967; but Perry 1966) and institutional structure of labor (market) allocation mechanisms. Evidence

for the dual labor market theory (Doeringer and Piore 1971) demonstrates two economies: one of salaried, large company, unionized employees, "sheltered" (Freeman, 1976) against business cycles, and a smaller, unorganized, and unprotected "reserve army," which, through its own job losses, "allows" the economy to adjust to business cycles. The importance of social relationships on the job for output-level and wage level are demonstrated for work group solidarity (Lysgaard, 1961), output norms (Homans 1950), and training structures (Stone 1974). Job skill level and task decision authority have been investigated as contributors to improved social status estimates (Cullen and Novick 1979) or to multidimensional status indicators (Spaeth (1979) uses separate "authority" and "complexity" dimensions orthogonal to prestige).

APPENDIX III

1970 Revised Occupational Codes
('n.e.c.' means not elsewhere classified)

001 ACCNT Accountants

002 ARCHIT Architects

005 PRGRM Computer specialists: computer programmers, computer systems analysts, other computer specialists, n.e.c.; operations and systems researchers (includes 003, 004, 005 and 055)

011 ENG-CIV Civil engineers

012 ENG-ELE Electrical and electronic engineers

013 ENG-IND Industrial engineers

022 ENG-SLS Sales engineers

023 ENG-C-M Aeronautical, astronautical, chemical, mechanical, metallurgical and materials, mining, petroleum, and other engineers, n.e.c. (includes 006, 010, 014, 015, 020, 021 and 023)

025 FOREST Foresters and conservationists

026 ADVISR Home and farm management advisors (includes 024 and 026)

031 LAWYER Judges and lawyers (includes 030 and 031)

032 LIBRARI Librarians, archivists and curators (includes 032 and 033)

054 SCI-NAT Mathematical specialists: actuaries, mathematicians, statisticians; life and physical scientists: agricultural scientists, atmospheric and space scientists, biological scientists, chemists, geologists, marine scientists, physicists and astronomers, other life and physical scientists, n.e.c. (includes 034-036, 042-045, 051-054)

056 LAB-REL Personnel and labor relations workers

062 DENTIST Dentists

065 PHYSCNS Physicians, medical and osteopathic

073 PHARM Chiropractors, optometrists, pharmacists, podiatrists, veterinarians, other health practitioners, n.e.c. (includes 061, 063, 064, 071, 072 and 073)

075 NURSE Dieticians and registered nurses (includes 074 and 075)

076 THERAPI Therapists

080 TEC-CLN Clinical laboratory technologists and technicians

085 TEC-HEL Dental hygientists, health record technologists, radiologic technologists, therapy assistants, other health technologist and technicians, n.e.c., embalmers (includes 081-085, 165)

090 CLERGY Clergymen, other religious workers, n.e.c. (includes 086 and 090)

096 SCI-SOC Social scientists: economists, political scientists, psychologists, sociologists, urban and regional planners, other social scientists, n.e.c. (includes 091-096)

100 SOC-WKR Social workers and recreation workers (includes 100 and 101)

140 PROFES College annd university teachers (includes 102-105, 110-115, 120-126, 130-135 and 140)

141 TEACH-A Adult education teachers

143 TEACH-E Elementary school, kindergarten and pre-kindergarten teachers includes 142, 143)

144 TEACH-S Secondary teachers

145 TEACH-O Teachers, other categories,n.e.c.

152 DRAFTS Draftsmen

153 TEC-ELE Electrical and electronic enginneering technicians

161 SURVEY Surveyors

162 TEC-LAB Technicians:
Agriculture and biological (exc. health), chemical, industrial engineering, mechanical engineering, mathematical technicians, other engineering and science technicians, n.e.c. (includes 150, 151, 154, 155, 156 and 162)

164 AIR-PIL Airplane pilots, air traffic controllers, flight engineers (includes 163, 164 and 170)

173 TEC-NEC Radio operators, numerical control tool programmers, other technicians (exc. health, engineering and science) (includes 171, 172 and 173)

174 COUNSL Vocational and educational counselors

180 ATHLET Athletes and kindred workers

183 DESIGN Designers

184 REPORT Editors and reporters

191 PHOTOG Photographers

192 ADVERT Public relations and publicity writers, advertising agents and and salesmen (includes 192 and 260)

194 ARTIST Actors, authors, dancers, musicians and composers, painters and sculptors, radio and television announcers; writers, artists and entertainers, n.e.c. (includes 175, 181, 182, 185, 190, 193 and 194)

195 RESRCH Not specified research workers

202 BANK-OF Assessors, controllers and treasurers in local public administration, bank officers and financial managers (includes 201 and 202)

205 BUYERS Buyers and shippers of farm products, buyers (wholesale and retail trade), purchasing agents and buyers, n.e.c. (includes 203, 205 and 225)

210 CREDIT Credit men

215 INSPECT Construction and other inspectors in public administration (includes 213 and 215)

216 MGR-BLD Building managers and superintendents

220 CLR-SUP Clerical supervisors and office managers, n.e.c. (includes 220 and 312)

222 ADM-PUB Health administrators, other public administration officials and administrators, n.e.c. (includes 212 and 222)

223 OFFIC Officials of lodges, societies and unions

224 POSTMST Postmasters annd mail superintendents

226 CONDUCT Ships' officers, pilots and pursers, railroad conductors (includes 221 and 226)

230 MGR-RES Restaurant, cafeteria and bar managers

231 MGR-RTL Retail trade sales managers and department heads

233 MGR-SLS Sales managers (exc. retail trade)

240 ADM-SCH Elementary, secondary and college administrators (includes 235 and 240)

261 PEDDL Auctioneers, demonstrators, hucksters and peddlers (includes 261, 262 and 264)

265 INSUR Insurance agents, brokers and underwriters

270 REL-EST Real esstate agents and brokers

271 SLS-BND Stock and bond salesmen

281 SLS-MFG Manufacturing sales representatives

282 SLS-WHL Wholesale trade sales representatives

283 SLS-CLK Retail trade sales clerks, newsboys, salesmen and sales clerks, n.e.c. (includes 266, 280 and 283)

284 SLS-RTL Retail trade salesmen

285 SLS-SVC Salesmen of services and construction

301 TELLER Bank tellers

305 CLK-BIL Billing clerks, bookkeepers, payroll and timekeeping clerks (includes 303, 305 and 360)

310 CASHIER Cashiers

314 CLK-CNT Counter clerks (exc. food)

320 INTERV Enumerators and interviewers

321 INVSGT Estimators and investigators, n.e.c., real estate appraisers, utilities meter readers (includes 321, 334 and 363)

323 PROD-CT Expediters and production controllers

325 CLK-FIL File clerks

326 ADJUST Bill and account collectors; insurance adjusters, examiners and investigators (includes 313 andd 326)

330 ASS-LIB Library attendants and assistants

332 MAILWKR Mail carriers and handlers (post office and non-post office) (includes 331 and 332)

333 MESSGS Messengers and office boys, telegraph messengers (includes 333 and 383)

341 OPR-OFF Office machine operators: bookkeeping and billing machine operators, calculating machine operators, tabulating machine operators (includes 341, 342 and 350)

355 OFF-NEC Duplicating machine operators, office machine operators, n.e.c. (includes 344 and 355)

361 CLK-PST Postal clerks

364 RECEPT Receptionists

374 CLK-SHP Shipping and receiving clerks

375 CLK-STA Proofreaders, statistical clerks (includes 362 and 375)

381 CLK-STK Stock clerks and storekeepers, weighers (includes 381 and 392)

382 AID-TCH Teachers aides, exc. school monitors

385 OPR-TEL Telephone operators, telegraph operators (includes 384 and 385)

390 AGN-TIC Ticket, station and express agents, vehicle dispatchers and starters (includes 315 and 390)

395 CLK-MSC Social welfare clerical assistants, miscellaneous and not specified clerical workers (includes 311, 394 and 395)

402 BAKERS Bakers

404 FORGE Forgemen, hammermen, heat treaters, annealers, metal molders, boilermakers (includes 404, 442, 446 and 503)

410 MASONS Brickmansons and stonemasons

413 FURNIT Cabinetmakers, furniture and wood finishers (includes 413 and 443)

415 CARPENT Carpenters

420 CARPET Carpet installers, floor layers, tile setters (includes 420, 440 and 560)

421 CEMNT-F Cement and concrete finishers

422 TYPESET Compositors and typesetters, electrotypers and stereotypers, photoengravers and lithoengravers (includes 422, 434 and 515)

423 APP-MAC Apprentices:
Printing trades, machinist, molders, pressmen, tool and die makers, and other unspecified apprentices (includes 423, 462, 504, 531, 562 and 572)

426 TEC-DEN Dental laboratory technicians

430 ELECTR Electricians

431 APP-CON Apprentices:
Brickmason and stonemason, carpenter, electrician, painter, plasterer, plumber and pipe fitter, sheetmetal, and other specified craft apprentices, n.e.c (includes 411, 416, 431, 511, 521, 523, 536 and 571)

433 ELE-LIN Electric power linemen and cablemen, telephone linemen and splicers (includes 433 and 554)

436 EXCAVT Bulldozer operators; cranemen, derrickmen and hoistmen; excavating, grading and road machine operators (includes 412, 424 and 436)

445 GLAZIER Glaziers

450 INSPCS Log and lumber inspectors, scalers and graders; other inspectors, n.e.c. (includes 450 and 452)

453 BOOKBND Bookbinders; engravers (exc. photoengravers); jewelers and watchmakers; opticians, lens grinders and lens polishers; piano and organ tuners and repairmen (includes 405, 435, 453, 506 and 516)

454 JOB-SET Metal job and die setters

455 ENG-LOC Locomotive engineers and locomotive firemen (includes 455 and 456)

461 MACHNST Machinists

471 MEC-AIR Aircraft mechanics and repairmen

472 MEC-AUT Automobile body repairmen, automobile mechanics, automobile mechanic apprentices, auto accessories installers (includes 472-474 and 401)

475 REPR-TV Data processing machine repairmen, office machine repairmen, radio and television repairmen (includes 475, 484 and 485)

480 REPR-FM Farm implement repairmen

481 REPR-HV Heavy equipment mechanics, loom fixers, railroad and car shop repairmen (includes 481, 483 and 486)

482 REPR-HS Air conditioning, heating and refrigeration repairmen; household appliance and accessory installlers and mechanics (includes 470 and 482)

495 REPR-MS Mechanic apprentices (exc. automobile), miscellaneous and not specified mechanics aand repairmen (includes 491, 492 and 495)

501 MILLWR Grain, flour and feed millers, millwrights (inncludes 501 and 502)

510 PAINTER Decorators and window dressers, construction and maintenance painters, paperhangers, plasterers, sign painters and letterers, dry wall installers and lathers (includes 425, 510, 512, 520, 543, and 615)

522 PLUMBER Plubmers and pipe fitters, shipfitters (includes 522 and 540)

530 PRESSMN Printing pressmen and plate printers, metal rollers and finishers

(includes 530 and 533)

534 ROOFER Roofers and slaters

535 WKR-MTL Blacksmiths, sheetmetal workers and tinsmiths (includes 403 and 535)

545 ENG-STA Motion picture projectionists, power station operators, stationary engineers, stationary firemen (includes 505, 525, 545 and 666)

546 STN-CUT Stone cutters and stone carvers

550 STC-CFT Structural metal craftsmen

551 TAILOR Furriers, shoe repairmen, tailors, upholsterers (includes 444, 542, 551 and 563)

552 INSTLLS Telephone installers and repairmen

561 TOOL-DI Pattern and model makers (exc. paper), tool and die makers (includes 514 and 561)

575 WKR-INS Asbestos and insulation workers, other craftmen and kindred workers, n.e.c. (includes 575 and 601)

603 OPR-MIN Blasters and powdermen; surveying chainmen, rodmen and axmen; earth drillers; mine operatives, n.e.c. (603, 605, 614 and 640)

604 OPR-CAN Bottling and canning operatives

610 CHECKER Manufacturing checkers, examiners and inspectors

611 IRONER Clothing ironers and pressers

612 OPR-CUT Cutting operatives, n.e.c.; meat cutter and butchers (exc. manufacturing) (includes 612 and 631)

613 DRESSMK Dressmakers and seamstresses (exe. factory), milliners (includes 613 and 636)

621 POLISHR Filers, polishers, sanders and buffers; manufactured article painters (includes 621 and 644)

623 GAS-STA Garage workers and gas station attendants, oilers and greasers (exe. automobile), parking attendants (includes 623, 642 and 711)

630 LAUNDRY Laundry and dry cleaning operatives, n.e.c.

633 BUTCHER Manufacturing meat cutters and butchers

635 PLATER Dryers; furnacemen, smeltermen and pourers; metal heaters; metal platers; mixing operatives (includes 620, 622, 626,

635 and 641)

645 WKR-PHO Photographic process workers

650 PRECIS Precision machine operatives: drill press operatives, grinding machine operatives, lathe and milling machine operatives, other precision machine operatives, n.e.c. (includes 650-653)

656 PUNCH Punch and stamping press operatives, riveters and fasteners (includes 656 and 660)

663 SEWER Sewers and stichers

664 OPR-TEX Shoemaking machine operatives; textile operatives; carding, lapping and combing operatives; knitters, loopers, and toppers; spinners, twisters and winders; weavers; other textile operatives, n.e.c. (includes 664, 670-674)

665 SOLDERR Solderers

680 WELDER Sawyers, welders and flame-cutters (includes 662 and 680)

681 OPR-WND Winding operatives, n.e.c

695 APP-CRP Carpenters' helpers (recode of 750)

701 SAILOR Sailors and deckhands, boatmen and canalmen (includes 661 and 701)

703 BUS-DRI Bus drivers, urban rail transport conductors and motormen (includes 705 and 714)

705 DELIV Deliverymen and routemen, taxicab drivers and chauffeurs (includes 705 and 714)

706 FORK-LF Fork lift and tow motor operatives

712 BRAKEMN Railroad brakemen

713 SWTCHMN Railroad switchmen

715 TRCK-DR Motormen (mine, factory, logging camp, etc.), truck drivers, teamsters laborers (includes 710, 715 and 763)

751 LAB-CON Construction laborers (exc. carpenters' helpers)

753 FR-HNDL Freight and material handlers

754 GARBAGE Garbage collectors

755 GARDEN Gardeners and groundskeepers (exc. farm)

761 LUMBER Lumbermen, raftsmen and woodchoppers

762 STK-HND Stock handlers

764 CARWASH Vehicle washers and equipment cleaners

770 WAREHOS Warehousemen, n.e.c.

780 LAB-MSC Miscellaneous laborers, industry not reported (see also 857-861)

801 FARMER Farmers (owners and tenants)

802 MGR-FRM Farm managers

822 LAB-FRM Farm laborers (wage workers, unpaid family workers), self-employed farm service workers (includes 822-824)

902 CLEANER Cleaners and charwomen

903 JANITOR Janitors and sextons

912 COOKS Cooks (exc. private household)

913 DISHWAS Dishwashers

915 WAITER Bartenders, food counter and fountain workers, waiters (includes 910, 914 and 915)

916 BUSBOY Other non-private household food service workers, n.e.c.; busboys (includes 911 and 916)

922 AID-HEL Health aides, exc. nursing; health trainees (includes 922, 923)

925 AID-NUR Nursing aides, orderlies and attendants

926 PRC-NUR Lay midwives, practical nurses (includes 924 and 926)

932 ATTEND Airline stewardesses, recreation and amusement attendants, other personal service attendants, welfare service aides (includes 931-933, 954)

934 OPR-ELE Baggage porters and bellhops, bootblacks, elevator operators (includes 934, 941 and 943)

935 BARBER Hairdressers and cosmetologists, barbers (includes 935 and 944)

950 HOUSEKP Boarding and lodging housekeepers, other housekeepers (exc. private household) (includes 940 and 950)

952 SCH-MON School monitors, personal service apprentices, recreation amusement ushers (includes 945, 952 and 953)

961 FIREMAN Firemen

962 WATCHMN Guards and watchmen, crossing guards and bridge tenders (includes 960 and 962)

964 POLICE Marshals and constables, policemen and detectives, sheriffs and bailiffs (includes 963-965)

982 PRI-HOU Private household housekeepers and cooks (includes 981, 982)

984 MAIDS Private household child care workers, laundresses, maids and servants; chambermaids and maids, exc. private households (includes 901, 980, 983, 984)

New Codes By Industry Subgroups

825-834 Managers and administrators, n.e.c.; funeral directors (includes 211 and 245)

825 MGRS-AD Self-employed managers of agriculture, forestry and fisheries, mining, construction, durable goods manufacturing: lumber and wood products, stone, clay and glass products

826 MGR-ADU Employed Managers of agriculture, forestry and and fisheries, mining, construction, durable goods manufacturing: lumber and wood products, stone, clay and glass products

827 MGR-MFN Managers of durable goods: metal industries; machinery, includes electrical; electrical equipment and supplies; transportation equipment; professional and photographic equipment, and watches;
Non-durable goods manufacturing

828 MGR-TSP Managers of transportation

829 MGR-UTL Managers of communications, utilities and sanitary services

830 MGR-WHL Managers of wholesale trade

831 MGRS-RF Self-employed managers of retail trade, finance, insurance and real estate

832 MGR-RF Employed managers of retail trade, finance, insurance and real estate

833 MGR-SVC Managers of business and repair services, personal services, entertainment and recreation services

834 MGR-PUB Managers of professional and related services, public administration

835-838 Secretaries (legal, medical, n.e.c.), stenograghers, typists (includes 370-372, 376 and 391)

835 SEC-ADU Secretaries for agriculture, forestry and fisheries, mining, construction, durable goods manufacturing: lumber and wood products, stone, clay and glass products and non-durable goods manufacturing

836 SEC-ELE Secretaries for durable goods manufacturing: electrical machinery, equipment and supplies; transportation equipment; not specified manufacturing industries

837 SEC-INS Secretaries for durable goods manufacturing: metal industries; non-electrical machinery; professional and photographic equipment, and watches

838 SEC-SVT Secretaries for transportation, communications, and other public utilites; wholesale and retail trade; finance, insurance and real estate; business and repair services; personal services; entertainment and recreation services; professional and related services; public administration

840-844 Farm foremen; foremen, n.e.c. (includes 441 and 821)

840 FOR-ADU Foremen of agriculture, forestry and fisheries, mining, construction, durable goods manufacturing: lumber and wood products, stone, clay and glass products

841 FOR-MFN Foremen of non-durable goods manufacturing

842 FOR-ELE Foremen of durable goods manufacturing: electrical machinery, equipment and supplies; transportation equipment; not specified manufacturing industries

843 FOR-INS Foremen of durable goods manufacturing: metal industries; non-electrical machinery; professional and photographic equipment, and watches

844 FOR-SVT Foremen of transportation, communications, and other public utilites; wholesale and retail trade; finance, insurance and real estate; business and repair services; personal services; entertainment and recreation services; professional and related services; public administration

847-851 Assemblers, manufacturing graders and sorters, produce graders and packers (exc. factory and farm), other packers and wrappers, meat wrappers (includes 602, 624, 625, 634 and 643)

847 ASM-ADU Assemblers, etc., in agriculture, forestry and fisheries, mining, construction, durable goods manufacturing: lumber and wood products, stone, clay and glass products

848 ASM-MFN Assemblers, etc., in non-durable goods manufacturing

849 ASM-ELE Assemblers, etc., in durable goods manufacturing: electrical machinery, equipment and supplies; transportation equipment; not specified manufacturing industries

850 ASM-INS Assemblers, etc., in durable goods manufacturing: metal industries; non-electrical machinery; professional and photographic equipment, and watches

851 ASM-SVT Assemblers, etc., in transportation, communications, and other public utilites; wholesale and retail trade; finance, insurance and real estate; business and repair services; personal services; entertainment and recreation services; professional and related services; public administration

852-856 Machine operatives (miscellaneous), not specified machine operatives (includes 690 and 692)

852 OPR-ADU Machine operatives in agriculture, forestry and fisheries, mining, construction, durable goods manufacturing: lumber and wood products, stone, clay and glass products

853 OPR-MFN Machine operatives in non-durable goods manufacturing

854 OPR-ELE Machine operatives in durable goods manufacturing: electrical machinery, equipment and supplies; transportation equipment; not specified manufacturing industries

855 OPR-INS Machine operatives in durable goods manufacturing: metal industries; non-electrical machinery; professional and photographic equipment, and watches

856 OPR-SVT Machine operatives in transportation, communications, and other public utilites; wholesale and retail trade; finance, insurance and real estate; business and repair services; personal services; entertainment and recreation services; professional and related services; public administration

857-861 Miscellaneous and not specified operatives, miscellaneous

and not specified laborers, animal caretakers, fishermen and oystermen, carpenters' helpers, longshoremen and stevedores (includes 694, 695, 740, 750, 752, 760, 780 and 785)

857 LAB-ADU Miscellaneous operatives and laborers in agriculture, forestry and fisheries, mining, construction, durable goods manufacturing: lumber and wood products, stone, clay and glass products

858 LAB-MFN Miscellaneous operatives and laborers in non-durable goods manufacturing

859 LAB-ELE Miscellaneous operatives and laborers in durable goods manufacturing: electrical machinery, equipment and supplies; transportation equipment; not specified manufacturing industries

860 LAB-INS Miscellaneous operatives and laborers in durable goods manufacturing: metal industries; non-electrical machinery; professional and photographic equipment, and watches

861 LAB-SVT Miscellaneous operatives and laborers in transportation, communications, and other public utilites; wholesale and retail trade; finance, insurance and real estate; business and repair services; personal services; entertainment and recreation services; professional and related services; public administration

APPENDIX IV JOB CHARACTERISTIC SCALE QUESTIONS AND COMPUTATIONS

DISC 12 - DECISION LATITUDE

1969

DISC 1
DISC 2
(see previous sheets)

1972

DISC 1
DISC 2
(see previous sheets)

1977

DISC 1
DISC 2
(see previous sheets)

DISC 12 Computations

1969

DISC 12 = DISC 1 + DISC 2

1972

DISC 12 = DISC 1 + DISC 2

1977

DISC 12 = DISC 1 + DISC 2

DISC1 - SKILL DISCRETION

1969

v63

Job requires that you keep learning new things

	A lot	(4)
	Somewhat	(3)
3	A little	(2)
4	Not at all	(1)
8	Dk	(9)
9	Na	(9)

v67

Job that requires a high level of skill

1	A lot	(4)
2	Somewhat	(3)
3	A little	(2)
4	Not at all	(1)
8	Dk	(9)
9	Na	(9)

1972

v97

Job requires that you keep learning new things

1	Not at all	(1)
2	A little	(2)
3	Somewhat	(3)
4	A lot	(4)
8	Dk	(9)
9	Na	(9)

v100

Job that requires a high level of skill

1	Not at all	(1)
2	A little	(2)
3	Somewhat	(3)
4	A lot	(4)
8	Dk	(9)
9	Na	(9)

1977

v3

Job requires that I learn new things

1	Strongly disagree	(1)
2	Disagree	(2)
4	Agree	(3)
5	Strongly agree	(4)
8	Dk	(9)
9	Na	(9)

v6

Job that requires a high level of skill

1	Strongly disagree	(1)
2	Disagree	(2)
4	Agree	(3)
5	Strongly disagree	(4)
8	Dk	(9)
9	Na	(9)

DISC 1 (continued)

1969

v72

A job that requires you to be creative

1	A lot	(4)
2	Somewhat	(3)
3	A little	(2)
4	Not at all	(1)
8	Dk	(9)
9	Na	(9)

v74

A job that to do repetitious things

1	A lot	(4)
2	Somewhat	(3)
3	A little	(2)
4	Not at all	(1)
8	Dk	(9)
9	Na	(9)

1972

v104

A job that requires you to be creative

1	Not at all	(1)
2	A little	(2)
3	Somewhat	(3)
4	A lot	(4)
8	Dk	(9)
9	Na	(9)

v106

A job that requires repetition

1	Not at all	(1)
2	A little	(2)
3	Somewhat	(3)
4	A lot	(4)
8	Dk	(9)
9	Na	(9)

1977

v11

My job requires that I be creative

1	Strongly disagree	(1)
2	Disagree	(2)
4	Agree	(3)
5	Strongly agree	(4)
8	Dk	(9)
9	Na	(9)

v35

My job requires that I do things over and over

1	Strongly disagree	(1)
2	Disagree	(2)
4	Agree	(3)
5	Strongly agree	(4)
8	Dk	(9)
9	Na	(9)

DISC 1 Computations

1969

DISC1 = (v63 + v67 + v72 - v74) * 2

1972

DISC1 = (v97 + v100 + v104 - v106) *2

1977

DISC1 = (v3 + v6 + v11 - v35) *4

DISC2 DECISION AUTHORITY

1969

v66

A lot of freedom over how you do your work

1	A lot	(4)
2	Somewhat	(3)
3	A little	(2)
4	Not at all	(1)
8	Dk	(9)
9	Na	(9)

v71

Allowed alot of decision on your own

1	A lot	(4)
2	Somewhat	(3)
3	A little	(2)
4	Not at all	(1)
8	Dk	(9)
9	Na	(9)

1972

v99

How much freedom does you job allow

1	Not at all	(1)
2	A Little	(2)
3	Somewhat	(3)
4	A lot	(4)
8	Dk	(9)
9	Na	(9)

v103

Allowed decision on your job

1	Not at all	(1)
2	A little	(2)
3	Somewhat	(3)
4	A lot	(4)
8	Dk	(9)
9	Na	(9)

1977

v5

I Have freedom to decide what I do on job

1	Strongly disagree	(1)
2	Disagree	(2)
4	Agree	(3)
5	Strongly agree	(4)
8	Dk	(9)
9	Na	(9)

v10

My responsibility to decide how much job gets done

1	Strongly disagree	(1)
2	Disagree	(2)
4	Agree	(3)
5	Strongly agree	(4)
8	Dk	(9)
9	Na	(9)

DISC2 (continued)

DISC2 Computations

1969

DISC2 = (v66 + v71) * 4

1972

DISC2 = (v99 + v103) * 4

1977

DISC2 = (v5 + v10) * 4

JOBSEC 2 - JOB INSECURITY

1969

v168

Job Steady

1	Steady	(1)
2	Seasonal	(2)
5	Frequent Layoffs	(3)
7	Other	(9)
8	Dk	(9)
9	Na	(9)

v421

Job Security is good

1	Very true	(1)
2	Somewhat true	(2)
3	Little true	(2)
4	Not True at all	(3)
9	Na	(9)

1972

v227

Work Steady

1	Steady	(1)
3	Seasonal	(2)
5	Frequent Layoffs	(3)
7	Other	(9)
8	Dk	(9)
9	Na	(9)

v637

Job security is good

1	Not true	(3)
2	Little true	(2)
3	Somewhat true	(2)
4	Very true	(1)
9	Na	(9)

1977

v94

Work Steady

1	Regular & Steady	(1)
2	Work When Its There	(1)
3	Seasonal	(2)
4	Both seasonal & Frequent Layoffs	(3)
5	Frequent Layoffs	(3)
6	Set own hours	(1)
7	Other	(9)
8	Dk	(9)
9	Na	(9)

v56

Job security is good

1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly agree
9	Missing
0	INAP

JOBSEC 2 Computations

1969

JOBSEC 2 = v168 + v421

1972

JOBSEC 2 = v227 + v637

1977

JOBSEC 2 = v94 + v56

SUPPOR - SOCIAL SUPPORT

1969

SUPSUP
CONSUP

1972

SUPSUP
CONSUP

1977

SUPSUP
CONSUP

1969

SUPPORT = CONSUP + SUPSUP

If (CONSUP eq 99) SUPPORT = SUPSUP + 2.408

If (SUPSUP eq 99) SUPPORT = CONSUP + 2.752

If (SUPSUP eq 99 and CONSUP eq 99) SUPPORT = 99

1972

SUPPORT = CONSUP + SUPSUP

If (CONSUP eq 99) SUPPORT = SUPSUP + 2.496

If (SUPSUP eq 99) SUPPORT = CONSUP + 2.934

If (SUPSUP eq 99 and CONSUP eq 99) SUPPORT = 99

197
SU = CONSUP + SUPSUP

If SUP eq 99) SUPPORT = SUPSUP + 2.777

If (SUPSUP eq 99) SUPPORT = CONSUP + 2.295

If (SUPSUP and CONSUP eq 99) SUPPORT = 99

SUPSUP - SUPERVISOR SUPPORT

1969

v431
Supervisor concerned about welfare of those under him

1	Very True	(4)
2	Somewhat True	(3)
3	Little True	(2)
4	Not At All True	(1)
9	NA	(9)

v89
Supervisor lets those under him alone unless they want help

1	Very True	(4)
2	Somewhat True	(3)
3	Little True	(2)
4	Not At All True	(1)
9	NA	(9)

v84
Supervisor takes a personal interest in those he supervises

1	Very True	(4)
2	Somewhat True	(3)
3	Little True	(2)
4	Not At All True	(1)
9	NA	(9)

v86
Supervisor encourages new ways of doing things

1	Very True	(4)
2	Somewhat True	(3)
3	Little True	(2)
4	Not At All True	(1)
9	NA	(9)

1972

v647
Supervisor concerned about welfare of those under him

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	DK	(9)
0	INAP	(0)

v142
Supervisor lets those under him alone unless they want help

1	Not At All True	(1)
2	Not Too True	(2)
3	Somewhat True	(3)
4	Very True	(4)
8	DK	(8)
9	NA	(9)
0	INAP	(0)

v139
Supervisor encourages new ways of doing things

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
8	DK	(8)
9	NA	(9)
0	INAP	(0)

1977

v66
Supervisor concerned about welfare of those under him

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	DK	(9)
0	INAP	(0)

v117
Supervisor lets those under him alone unless they want help

1	Not At All True	(1)
2	Not Too True	(2)
3	Somewhat True	(3)
4	Very True	(4)
8	DK	(8)
9	NA	(9)
0	INAP	(0)

v114
Supervisor encourages new ways of doing things

1	Not At All True	(1)
2	Not Too True	(2)
3	Somewhat True	(3)
4	Very True	(4)
8	DK	(8)
9	NA	(9)
0	INAP	(0)

SUPSUP (continued)

1969

1972

v654
Supervisor is friendly

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	NA	(9)
0	INAP	(0)

v143
Supervisor pays attention to what you are saying

1	Not At All True	(1)
2	Not Too True	(2)
3	Somewhat True	(3)
4	Very True	(4)
8	DK	(8)
9	NA	(9)
0	INAP	(0)

v655
Supervisor helpful to me in getting my job done

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	NA	(9)
0	INAP	(0)

v650
Supervisor successful in getting people to work together

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	NA	(9)
0	INAP	(0)

1977

v73
Supervisor is friendly

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	NA	(9)
0	INAP	(0)

v121
Supervisor talks things over with people he supervises before making a decision

1	Not At All True	(1)
2	Not Too True	(2)
3	Somewhat True	(3)
4	Very True	(4)
8	DK	(8)
9	NA	(9)
0	INAP	(0)

v74
Supervisor helpful in getting job done

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	NA	(9)
0	INAP	(0)

v69
Supervisor successful in getting people to work together

1	Not At All True	(1)
2	Little True	(2)
3	Somewhat True	(3)
4	Very True	(4)
9	NA	(9)
0	INAP	(0)

SUPSUP (continued)

SUPSUP Computations

1969

$$v431x = \frac{(v431 - 1)}{(3 * .3299)}$$

$$v89x = \frac{(v89 - 1)}{(3 * .2706)}$$

$$v84x = \frac{(v84 - 1)}{(3 * .2981)}$$

$$v86x = \frac{(v86 - 1)}{(3 * .3487)}$$

1972

$$v647x = \frac{(v647 - 1)}{(3 * .3225)}$$

$$vv142x = \frac{(v142 - 1)}{(3 * .2683)}$$

$$v139x = \frac{(v139 - 1)}{(3 * .3266)}$$

$$v654x = \frac{(v654 - 1)}{(3 * .2609)}$$

$$v143x = \frac{(v143 - 1)}{(3 * .2677)}$$

$$v655x = \frac{(v655 - 1)}{(3 * .2976)}$$

$$v650x = \frac{(v650 - 1)}{(3 * .3024)}$$

Assign missing

1977

$$v66x = \frac{(v66 - 1)}{(3 * .3207)}$$

$$v117x = \frac{(v117 - 1)}{(3 * .2655)}$$

$$v114x = \frac{(v114 - 1)}{(3 * .3257)}$$

$$v73x = \frac{(v73 - 1)}{(3 * .2888)}$$

$$v121x = \frac{(v121 - 1)}{(3 * .3309)}$$

$$v74x = \frac{(v74 - 1)}{(3 * .3019)}$$

$$v69x = \frac{(v69 - 1)}{(3 * .3197)}$$

Assign missing v66x to v69x (99)

Count rmissl = v 66x to v69x (99)

$$\text{If (rmissl le 2) SUPSUP} = \frac{(v74x + v114x + v66x + v69x + v73x + v117x + v121x) - (99 * rmissl)}{(7 - rmissl)}$$

If (rmissl gt 2) SUPSUP = 99

COWSUP - COWORKER SUPPORT

1969

v76
Help and assistance from those with whom I work

1 Enough	(5)
5 Not Enough	(1)
8 DK	(8)
9 NA	(9)

v409
I am given enough chances to make friends

1 Very True	(4)
2 Somewhat True	(3)
3 Little True	(2)
4 Not At All True	(1)
NA	(9)

v411
Coworkers are friendly and helpful

1 Very True	(4)
2 Somewhat True	(3)
3 Little True	(2)
4 Not at All True	(1)
9 NA	(9)

1972

v625
I am given enough chances to make friends

1 Not True At All	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)

v656
People who work with me are helpful in getting job done

1 Not At All True	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)

v657
People I work w/ are competant in doing their jobs

1 Not At All True	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)

1977

v45
I am given a lot of chances to make friends

1 Not At All True	
2 Little True	
3 Somewhat True	
4 Very True	
9 NA	
0 INAP	

v75
People I work with are helpful in getting job done

1 Not At All True	
2 Little True	
3 Somewhat True	
4 Very True	
9 NA	
0 INAP	

v76
People I work w/ are competant in doing their jobs

1 Not At All True	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)
0 INAP	(0)

COWSUP (continued)

1969

1972

v652
People I work w/ take a personal interest in me

1 Not At All True	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)

v658
People I work with are friendly

1 Not At All True	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)

1977

v71
People I work w/ take a personal interest in me

1 Not At All True	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)
0 INAP	(0)

v77
People I work with are friendly

1 Not At All True	(1)
2 Little True	(2)
3 Somewhat True	(3)
4 Very True	(4)
9 NA	(9)
0 INAP	(0)

COWSUP Computations

1969

$$v76x = \frac{(v76 - 1)}{(4 * .3947)} \qquad v409x = \frac{(v409 - 1)}{(3 * .2990)} \qquad v411x = \frac{(v411 - 1)}{(3 * .2330)}$$

Assign missing v76x to v411x (99)

Count number missing = v76x to v411x (99)

If (nmiss< 1), $COWSUP = \frac{(v76x + v409x + v411x) - (99 * nmiss)}{(3 - nmiss)}$

If (nmiss > 1), COWSUP = 99

CONSUP Computations (continued)

1972

$$v625x = \frac{(v625 - 1)}{(3 * .2942)} \qquad v652x = \frac{(v652 - 1)}{(3 * .3088)}$$

$$v656x = \frac{(v656 - 1)}{(3 * .2613)} \qquad v658x = \frac{(v658 - 1)}{(3 * .2103)}$$

$$v657x = \frac{(v657 - 1)}{(3 * .2528)}$$

Assign missing v625x to v658x (99)

Count nmiss = v625x to v658x (99)

If (nmiss $\leq$ 2), CONSUP = $\frac{(v625x + v656x + v657x + v652x + v658x) - (99 * nmiss)}{(5 - nmiss)}$

If (nmiss > 2) CONSUP = 99

1977

$$v45x = \frac{(v45 - 1)}{(3 * .2780)} \qquad v71x = \frac{(v71 - 1)}{(3 * .3023)}$$

$$v75x = \frac{(v75 - 1)}{(3 * .2720)} \qquad v77x = \frac{(v77 - 1)}{(3 * .2336)}$$

$$v76x = \frac{(v76 - 1)}{(3 * .2572)}$$

Assign missing v45x to v77x (99)
Count nmiss = v45x to v77x (99)
If (nmiss $\leq$ 2), CONSUP = $\frac{(v45x + v75x + v76x + v71x + v77x) - (99 * nmiss)}{(5-nmiss)}$

If (nmiss > 2), CONSUP = 99

Hrs. Wk. - HOURS PER WEEK

1969

v170
Hrs/Wk that R works not counting time off for meals.

150	15 hrs.	(150)
.		
.		
.		
985	$\geq$ 98.5	(985)
998	DK	(998)
999	NA	(999)

1972

v229
Hrs/Wk that R works not including time off for lunch.

150	15 hrs.	(150)
.		
.		
.		
985	98.5	(985)
997	> 99	(997)
998	DK	(998)
999	NA	(999)

1977

v144
Hrs/Wk that R works not including time off for lunch.

200	20 hrs.	(200)
.		
.		
.		
985	98.5	(985)
997	> 99	(997)
998	DK	(998)
999	NA	(999)

Hrs. Wk. Computations

1969

Hrs/Wk = v170/10
If (v170 EQ 998 or v170 EQ 999)
Hrs/Wk = 99

1972

Hrs/Wk = v229
If(Hrs/Wk LE 997) Hrs/Wk = Hrs/Wk/10
If (Hrs/Wk EQ 997) Hrs/Wk = 98
Recode Hrs/Wk (998,999 = 99)

1977

Hrs/Wk = v144
Recode Hrs/Wk (997 = 980) (998 = 999)
If (Hrs/Wk NE 999) Hrs/Wk = Hrs/Wk/10
If (Hrs/Wk = 999) Hrs/Wk = 99

Physdem - PHYSICAL EXERTION (variable scored negatively)

1969

v69
A job that requires lots of physical effort?

1 A lot	(1)
2 Somewhat	(2)
3 A little	(3)
4 Not at all	(4)
8 DK	(8)
9 NA	(9)

1972

v102
Does your job require lots of phsycial effort?

1 Not at	(4)
2 A little	(3)
3 Somewhat	(2)
4 A lot	(1)
9 DK	(9)

1977

Missing

Physdem Computations

1969
Physdem = v69

1972
Physdem = v102

1977
Physdem = 99

PHYS 1 - NOISE EXPOSURE

1969

v211, v213, v215

Exposure to dangerous or unhealthy conditions

.
.
.

308 Excessive Noise

.
.
.

v212, v213, v215

How severe a problem?

1 No problem at all	(1)
2 Slight	(2)
3 Sizeable	(3)
4 Great	(4)

1972

v277, v279, v281

Exposure to dangerous or unhealthy conditions

.
.
.

308 Excessive Noise

.
.
.

v278, v280, v282

How severe a problem?

1 No problem at all	(1)
2 Slight	(2)
3 Sizeable	(3)
4 Great	(4)

1977

v260

Problems with to much noise

1 No problem at all	(0)
2 Slight problem	(1)
3 Sizeable	(1)
4 Great	(1)

PHYS 1 Computations

1969

If $\left(\begin{Bmatrix} v211 \\ v213 \\ v215 \end{Bmatrix}\right.$ eq 308 & $\left.\begin{Bmatrix} v212 \\ v214 \\ v216 \end{Bmatrix} = 2,3,4\right)$ PHYSI = 1

1972

If $\left(\begin{Bmatrix} v277 \\ v279 \\ v281 \end{Bmatrix}\right.$ eq 308 & $\left.\begin{Bmatrix} v278 \\ v280 \\ v282 \end{Bmatrix} = 2,3,4\right)$ PHYSI = 1

1977

PHYSI = v260

PHYS 2 - TEMPERATURE EXTREMES

1969

v211, v213, v215

Exposure to dangerous or unhealthy conditions

⋮

309 Extremes of Temperature or Humidity

312 Natural Hazards

⋮

v212, v214, v216
How severe a problem?

1	No problem at all	(1)
2	Slight	(2)
3	Sizeable	(3)
4	Great	(4)

1972

v277, v279, v281

Exposure to dangerous or unhealthy conditions

⋮

309 Extremes of Temperature or Humidity

312 Natural Hazards

v278, v280, v282
How severe a problem?

1	No problem at all	(1)
2	Slight	(2)
3	Sizeable	(3)
4	Great	(4)

1977

v252

Problem of working outside in bad weather

1	No problem at all	(0)
2	Slight	(1)
3	Sizeable	(1)
4	Great	(1)

PHYS2 Computations

1969

PHYS2 = 0

If ({v211, v213, v215} eg 309 or 312 and {v212, v214, v216} eg 2,3, or 4) PHYS2 = PHYS2 + 1

1972

PHYS2 = 0

If ({v277, v279, v281} eg 309 or 312 and {v278, v280, v282} eg 2,3, or 4) PHYS2 = PHYS2 + 1

1977

PHYS2 = v252 + v254

PHYS 3 - HOSTILITY - FROM OUTSIDERS

1969

v211, v213, v715

Dangerous or unhealthy conditions

⋮

201 Danger from animals
202 Violence of abuse from customers
203 Violence from others
297 Other dangers from people or animals

v212, v214, v216
How severe a problem?

1	No problem at all	(1)
2	Slight	(2)
3	Sizeable	(3)
4	Great	(4)

1972

v277, v279, v281

Dangerous or unhealthy conditions

⋮

201 Danger from animals
202 Violence or abuse from customers
203 Violence from others
297 Other Dangers from people or animals

v278, v280, v282
How severe a problem?

1	No problem at all	(1)
2	Slight	(2)
3	Sizeable	(3)
4	Great	(4)

1977

v268

Risk of personal attack by people or animals

1 No problem at all
2 Slight
3 Sizeable
4 Great

PHYS 3 Computations

1969

PHYS3 = 0

If ({v211, v213, v215} eg 201, 202, 203 or 297 and {v212, v214, v216} eg 2,3 or 4) PHYS3 = PHYS3

1972

PHYS3 = 0

If ({v277, v279, v281} eg 201, 202, 203 or 297 and {v278, v280, v282} = 2,3,or 4) PHYS3 = PHYS3 +

1977

PHYS3 = v278

PHYS 4 - HAZARDOUS CONDITIONS

1969

v211, v213, v215

1972

v277, v279, v281

1977

v246, v248, v250, v258
v262, v270, v256
v264, v266

Hazardous/Dangerous Condition

101 Inadequate protective equipment
102 Inadequate shoring in mining
103 Inadequately guarded electrical apparatus
104 Inadequate shielding from radiation
105 Working with unlabed chemicals
106 Inadequate training/practice of safety features
107 Inadequate guards on machinery
108 Inadequately repaired equipment
109 Inadequate warning of hazardous conditions

197 Other dangers attributed to inadequate procedures
 0 Inherently dangerous materials
301 Inherently dangerous equipment
302 Inherently dangerous methods
303 Hazardous exposure
304 Tasks assigned regardless of physical limitations
305 Inadequate help in performing activities
306 Poor sanitation
307 Slippery floors
310 Inadequate space
311 Placement hazards
 4 Exposure to communicable diseases
 R specifies injury but does not name hazard

How severe a problem is

v246 Dangerous chemicals
v248 Fire, burns & shocks
v250 Air pollution on the job
v258 Things stored dangerously
v262 Dangerous equipment
v270 Dangerous work methods
v256 Badly maintained work areas
v264 Risk of catching disease
v266 Risk of traffic accidents

1 No problem at all (0)
2 Slight (1)
3 Sizeable (1)
4 Great (1)

1969

v212, v214, v216

1972

v278, v280, v282

1977

How severe a problem

1 No problem (1)
2 Slight (2)
3 Sizeable (3)
4 Great (4)

1 No problem (1)
2 Slight (2)
3 Sizeable (3)
4 Great (4)

PHYS 4 Computations

1969

PHYS 4 = 0
If({v211, v213, v215} eq (see code above) and {v212, v214, v216} eq 2, 3, or 4), PHYS 4 = PHYS 4+1

1972

PHYS 4 = 0
If({v277, v279, v281} eq (see code above) and {v278, v280, v282} eq 2, 3, or 4), PHYS 4 = PHYS 4+1

1977

PHYS 4 = (v246 + v248 + v250 + v256 + v258 + v262 + v264 + v266 + v270)

APPENDIX V : APPROXIMATING ANCOVA STANDARD ERRORS

For the ANOVA model, the standard error of the j-th occupation mean is estimated to be

$$SE_{\bar{Y}.j} = \sqrt{\Sigma_{i=1}^{n_j}(Y_{ij}-\bar{Y}.j)^2/(n_j-1)n_j} = S_j/\sqrt{n_j} \quad . \qquad (A-1)$$

where S_j is the unbiased sample estimate of the standard deviation of those individuals in the j-th occupation.

Since $\hat{Y}_{ij} = \bar{Y}.j$, this is also the standard error of the estimate as an estimate of the "true predicted value." We can also estimate the standard error of estimate, how good a prediction $\hat{Y}_{ij}$ is of an individual's score, Y_{ij}:

$$SE_{\hat{Y}_{ij}} = \sqrt{S^2_{\bar{Y}.j} + \Sigma_{i=1}^{n_j}(Y_{ij}-\bar{Y}.j)^2/(n_j-1)} = S_j\sqrt{1+1/n_j} \quad . \qquad (A-2)$$

However, this latter estimate ignores the fact that we do not care about our inability to predict the measurement error in Y_{ij}. Equation A-2 can be modified to estimate the standard error of $\hat{Y}_{ij}$ as a predictor of an individual's true job score, Y^*_{ij}:

$$SE_{\hat{Y}^*_{ij}} = \sqrt{S^2_{\bar{Y}.j} + \Sigma_{i=1}^{n_j}(Y^*_{ij}-\bar{Y}.j)^2/(n_j-1)} = S_j\sqrt{\alpha+(1/n_j)}, \qquad (A-3)$$

where α is the reliability of the job dimension scale (Table 1).

It is substantially more difficult to calculate the appropriate standard errors for the ANCOVA model estimates. However, the coefficients of the covariates will have very small standard errors compared to the standard errors of the adjusted group means and therefore the dominant component of the error will be analogous to that computed for the ANOVA model above.

The large number of occupation categories (approximately 200) make the precise estimation of standard errors prohibitively complex/expensive. We therefore approximate the standard error of the j-th adjusted occupation mean as

$$SE_{\bar{Y}_{\cdot j(adj)}} \approx \sqrt{\Sigma_{i=1}^{n_j}[Y_{ij(adj)} - \bar{Y}_{\cdot j(adj)}]^2/(n_j - 1)n_j} = S_{j(adj)}/\sqrt{n_j}, \quad \text{(A-4)}$$

where $S_{j(adj)}$ is the standard deviation of the scores for individuals in the j-th occupation after they have been adjusted for differences attributable to the demographic variables $Y_{ij} - \Sigma_k B_k(X_{ijk} - \bar{X}_{\cdot\cdot k})$. This will generally be the dominant, but not only, component of the standard errors of our predicted job scores as estimates of the true predicted scores. Similarly, we have adapted the other ANOVA equations to give us approximate (though probably slightly low*) estimates of the standard errors of $\hat{Y}_{ij}$ and $\hat{Y}^*_{ij}$:

$$SE_{\hat{Y}_{ij}} = S_{j(adj)}\sqrt{1 + 1/n_j} \quad \text{(A-5)}$$

and

$$SE_{\hat{Y}^*_{ij}} = S_{j(adj)}\sqrt{a + 1/n_j}\ . \quad \text{(A-6)}$$

In summary, the $S_{\bar{Y}_{\cdot j}}$ and $S_{\bar{Y}_{\cdot j(adj)}}$ remind us that our predicted job scores contain some error that is due to the effect of sampling variability on our estimates of the ANOVA/ANCOVA model parameters. This slightly inflates the variance of our estimated job scores ($\hat{Y}_{ij}$) (relative to the "true" estimated job scores, $\hat{Y}^*_{ij}$). On the other hand, both $\hat{Y}_{ij}$ and $\hat{Y}^*_{ij}$ are missing both the unexplained reliable variance of Y^*_{ij} and the unreliable variance of the observed Y_{ij}. This can perhaps best be summarized by the following equations:

---

*The standard errors of the coefficients of the covariates will have a greater impact on the standard errors of the estimated scores for the i-th person if his/her scores on the covariates are extreme.

$$\hat{Y}_{ij} = \hat{Y}^{*}_{ij} + \delta_{ij} \quad , \tag{A-7}$$

where $\delta_{ij} = \{\bar{Y}_{\cdot j(adj)} - \mu_{j(adj)}\} + \sum_k (B_k - \beta_k)(X_{ijk} - \bar{X}_{\cdot\cdot k})$,

$$Y^{*}_{ij} = \hat{Y}^{*}_{ij} + \eta_{ij} \quad , \tag{A-8}$$

where η_{ij} = unexplained residual of a persons's <u>true</u> job score;

$$Y_{ij} = Y^{*}_{ij} + \epsilon_{ij} \quad , \tag{A-9}$$

where ϵ_{ij} = measurement error in a person's observed job score. Verbally (working from right to left), each person's score (Y) is made up of two components, a true score (Y^{*}) and a measurement error (ϵ). The true score, in turn, is made up of a component which is associated with occupational category and demographic characteristics ($\hat{Y}^{*}$) and an unpredictable component (η). Finally, our estimate ($\hat{Y}$) is based on the predictable component of the true score ($\hat{Y}^{*}$) but is subject to the effect (δ) of sampling errors on our estimates of the prediction equation.

Figure A-1 : Complete Measurement Model for Job Characteristics

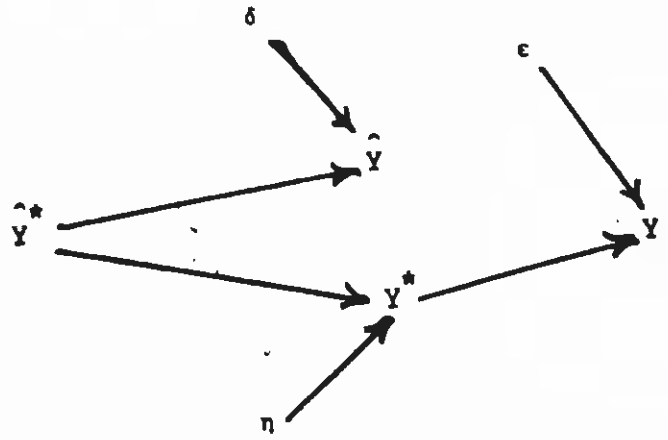


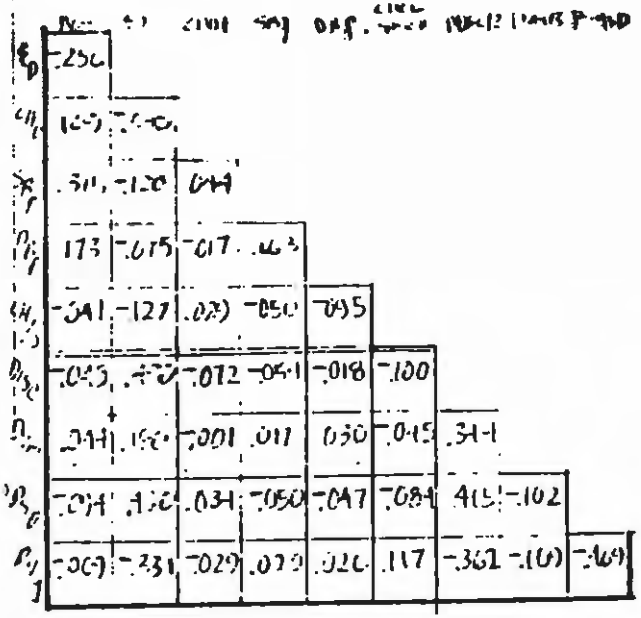
Figure A-1 portrays the model defined by equations A-7, A-8 and A-9, and illustrates how the estimated $\hat{Y}_{ij}$ contain some "undesirable" variance (σ^2_{δ}) and lack the "unexplained" reliable variance (σ^2_{η}).

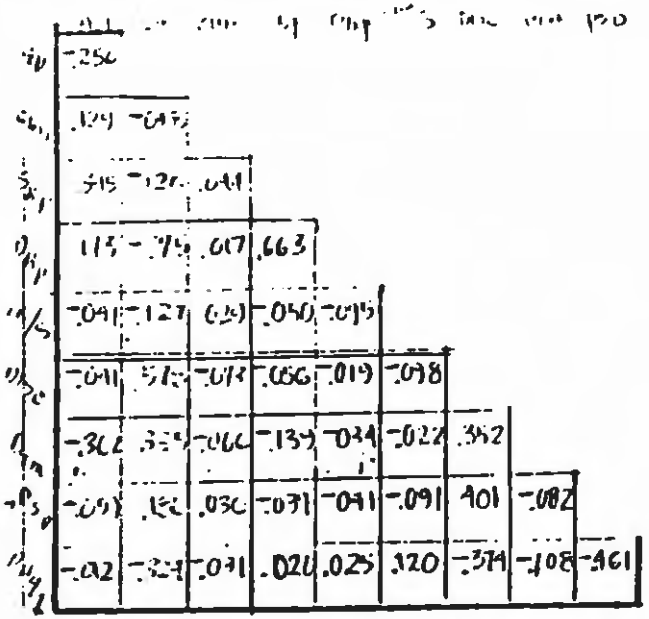
MEANS

RECONSTITUTED

(FIANES)

WEIGHTED





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