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Comparing Group and Individual Level Assessments of Job Characteristics in Testing the Job Demand-Control Model: A Multilevel Approach

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This article describes a test of Karasek's Job Demand-Control (JD-C) Model using both group and individual level assessments of job characteristics. By group assessments, we mean aggregated individual data. A random sample from general hospitals and nursing homes included 16 institutions, 64 units, and 1489 health care workers (82% response). Because of the hierarchically nested data structure (i.e., institutions, units, and individuals) the research questions and hypothesis were tested in multilevel regression analyses (VARCL). The results revealed both group level and individual level effects with regard to psychological outcomes, and stressed the usefulness of multilevel techniques. Karasek's JD-C Model was partly confirmed by finding two interaction effects at group level and at individual level with regard to job satisfaction and work motivation, respectively. The discussion focuses on theoretical, methodological, and practical implications of multilevel modeling with respect to the JD-C Model.

KEY WORDS: job demand-control model; multilevel analysis; workstress; health care.

INTRODUCTION

In order to redesign jobs or workplaces, researchers were always interested in how job characteristics affect working people. In the last few decades, many organizational research studies have shown that the pres-

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ence or absence of certain job characteristics (e.g., job demands and job autonomy) may lead to attitudinal and behavioural reactions, such as job satisfaction, exhaustion, health complaints, and even illness or disability (e.g., Hackman & Oldham, 1980; Karasek & Theorell, 1990; Schnall, Landsbergis, & Baker, 1994; Siegrist, Peter, Junge, Cremer, & Seidel, 1990; Warr, 1987). As a consequence, several theoretical models have been developed to understand the relationship between such job characteristics and employee reactions (cf. Kahn & Byosiere, 1992). In general, these models can be described as situation-centered or person-centered (cf. Warr, 1987). Situation-centered models focus primarily on explanatory factors or events outside a particular worker, while person-centered models seek explanations in the person whose actions are being studied (e.g., cognitions, habits, feelings, and needs).

A situation-centered model on which much of the current job redesign research and job stress research is based is the Job Demand-Control (JD-C) Model, developed by Karasek (1979). In its basic form, the model postulates that the primary sources of job stress lie within two basic characteristics of the job itself: (1) psychological job demands, and (2) job decision latitude. Job demands are defined as psychological stressors that are present in the work environment (e.g., workload). Job decision latitude, or job control, is defined as "the working individual's potential control over his tasks and his conduct during the working day" (Karasek, 1979, pp. 289-290).

Psychological strains are a consequence of the joint effects of the demands of a job and the range of job control available to the employee. These joint effects are also called interaction effects. The first major prediction of the JD-C Model is that the strongest aversive job-related strain reactions (like exhaustion, job-related anxiety, and health complaints) will occur when job demands are high and worker's control is low (i.e., high strain jobs). The second prediction of the model, which is sometimes overlooked, is that motivation, learning, and personal growth will occur in situations where both job demands and worker's control are high (i.e., active jobs).

Tests of the JD-C Model can be roughly divided into two categories, namely (1) multi-occupation studies, and (2) single-occupation studies (cf. De Jonge, 1995; Jones & Fletcher, 1996). The former kind of studies are usually large-scale examinations of national surveys that mainly focus on cardiovascular diseases. These studies frequently use an occupation level of analysis. The latter refers to individual level self-report studies that focus on attitudinal outcomes (e.g., job satisfaction and work motivation), behavioural outcomes (e.g., absenteeism and smoking consumption), and physiological outcomes (e.g., blood pressure and muscle tension). A large number of studies evaluating the JD-C Model failed to provide clear and unambiguous support (De Jonge & Kompier, 1997; Jones & Fletcher, 1996). Several conceptual as well as methodological criticisms have been expressed in the literature that might explain the inconclusive results. First, there is some doubt as to the conceptualization and operationalization of job demands and job decision latitude, particularly in the multi-occupation studies. Job demands as used by Karasek seem to be a mixture of job stressors, job complexity, and lack of control (Jones & Fletcher, 1996; Kasl, 1996). For instance, "hectic work" may have different meanings depending on the particular job of the respondent. In addition to this, the original scale of Karasek (1979, 1985) includes not only purely descriptive items, but also affective items, which may lead to spurious relationships with the dependent variables (cf. Wall, Jackson, Mullarkey, & Parker, 1996). Job decision latitude reflects the term "job autonomy" as it is used in the job redesign tradition, but the operationalization of this construct also contains elements like skill level, skill variety, and even job scope or job complexity (Frese, 1989; Ganster, 1989, 1995; Kasl, 1996). So, the measurement of both job demands and job decision latitude may be confused with other job characteristics.

Second, in multi-occupation studies, results may be confounded with, for instance, socioeconomic status and health behaviour of the workers. Jobs concomitantly high in demands and low in control are likely overrepresented by employees of low socioeconomic class and low health behaviour who share other risks for cardiovascular diseases (e.g., Siegrist et al., 1990). Third, the finding of significant interaction effects of job demands and job decision latitude may be affected by the use of different methods and/or different kinds of interaction terms (e.g., Kasl, 1996; Landsbergis, Schnall, Warren, Pickering, & Schwartz, 1994). More specifically, both analysis of variance and regression analysis have been carried out. In general, the first method produces results that are relatively often in favor of the JD-C Model. However, it has been argued that interactions ideally should be tested with moderated regression analysis (Aiken & West, 1991; Landsbergis et al., 1994). Quite often, studies that use the latter do not yield positive results (e.g., Payne & Fletcher, 1983; Spector, 1987). These differences in results can be explained by power differences between different statistical methods. Fourth, it is also possible that the inconsistent—interactive—findings could be due to one or more moderator variables influencing relations between job characteristics and outcomes (e.g., personality characteristics or workplace social support). A number of research studies have started in order to investigate these moderating effects, some of them with quite promising results (see Johnson, 1989; Jones & Fletcher, 1996; Parkes, 1991; De Rijk, Le Blanc, Schaufeli, & De Jonge, 1998).

Finally, an alternative explanation for the lack of consistency may be the assessment of job characteristics. Basically, the JD-C Model is situation-centered in that it emphasizes the particular role of the work environment in the prediction of job-related strain. It is self-evident that in cases where the aim is to redesign work independently of a particular worker, one needs more objective parameters which are able to show to have an impact on people's behaviour (Frese & Zapf, 1994). In other words, job demands and job control are, in theory, characteristics of jobs rather than characteristics of people.

Job demands and job control generally have been measured by means of self-report questionnaires. However, the main problem with such questionnaire instruments is that—as reflections of the objective work environment—they are more prone to bias than objective instruments. Self-report questionnaires measure job characteristics as perceived by the individual worker and may therefore not reflect the objective task accurately (Karasek & Theorell, 1990). For instance, someone can work in a job with high demands, and not report feelings of high workload.

Consequently, the methodology of the JD-C studies (the multi-occupation studies in particular) has varied considerably. Most studies rely heavily on the individual's perception or description of job characteristics (cf. Söderfeldt, Söderfeldt, Jones, O'Campo, Muntaner, Ohlson, & Warg, 1996). A few have highlighted the group's perception or description as a reflection of the objective environment (cf. De Jonge & Kompier, 1997; Schnall et al., 1994). This point will be discussed in more detail in the next section.

THE ASSESSMENT OF JOB CHARACTERISTICS

The job characteristics of the JD-C Model have been measured in two different ways: (1) "objective," and (2) "subjective" (Karasek & Theorell, 1990; Kristensen, 1995). "Objective" and "subjective" have been put in quotation marks, because they are used inconsistently in the literature on work-stress. So-called "objective" job characteristics may be defined as ones which are assessed independently of the job incumbent (cf. Frese & Zapf, 1988, 1994; Spector, 1992). Examples are physical and social characteristics of the work environment or expert ratings. Accordingly, "subjective" job characteristics are dependent on employee's cognitive and emotional processing (like appraisals), and their ability in coping (Frese & Zapf, 1988, 1994; Lazarus, 1995).

Currently, the objective method is carried out through (1) direct independent measurement, and (2) observers' ratings (e.g., Frese & Zapf, 1988; Kristensen, 1995; Schnall et al., 1994; Theorell & Karasek, 1996). The main problem with direct measurement of objective characteristics is that some aspects are difficult to express in concrete physical terms (Warr, 1987). For example, job autonomy and job clarity do not provide usable general markers. The second approach seems to be objective as mentioned above, but may be influenced by observers' bias. The measurement yields incomplete and partially invalid information, due to limited observation time or space and the effects of the observation itself (Frese & Zapf, 1988). Additionally, observers' ratings seem to suffer from stronger halo and stereotyping effects than subjects' assessments (Frese, 1985; Semmer, Zapf, & Greif, 1996; Spector, Brannick, & Coovert, 1989).

The subjective method is usually carried out by means of self-report questionnaires. This kind of measurement has several problems as well (e.g., Frese, 1985; Frese & Zapf, 1988; Kasl, 1989, 1996; Spector, 1992; Zapf, 1989), such as: (1) conceptual overlap between independent and dependent measures in that both measures reflect the same construct; (2) common method variance, because the information is derived from the same source (e.g., central tendency, acquiescence); (3) influence of a third variable that causes a spurious relationship (e.g., a personal trait); (4) the potential influence—or alteration—of the estimation of job characteristics due to the presence of an outcome variable (e.g., health complaints); (5) possible effect of demand characteristics of the research context and experimenter effects, resulting in false correlations between job characteristics and outcome variables; (6) job incumbents may be so used to their work situation that they deny some of the occupational hazards.

Spector (1992) argued that more work needs to be done exploring the accuracy of reports, both from the perspective of the job incumbent and from alternative sources to reflect the work conditions. One way to avoid the above-mentioned problems as far as possible is to look for such alternative sources. So-called *group assessments* seem to be very useful in measuring job characteristics (Frese, 1985, 1989; Frese & Zapf, 1988; Spector, 1992). By group assessments, we mean that the scores of job incumbents with the same job and working in nearly identical workplaces are aggregated into one general score. The group assessments can be described as the group estimates of the respective job characteristic for each job incumbent. These measures refer to that part of a particular job characteristic that different workers doing nearly the same job have in common (see also Semmer et al., 1996). In other words, group assessments are based on the concept of the ideal typical worker (i.e., an average worker with sufficient skills to perform his or her tasks). According to Frese and Zapf (1988, 1994), group assessments are more objective measures in the sense that the influence of idiosyncratic—individual—perceptions and possibly illusory answers are reduced. In addition to this, the expertise of workers is taken into account and problems of brief periods of observation are avoided. Finally, group assessments seem to be less subject to methodological problems such as attenuation, because unsystematic error variance is reduced. Thus, group data are likely to be more reliable than individual assessments.

Theoretical justification for considering group assessments as more objective measures of the two job characteristics in the JD-C Model can be found in the literature on social and interactional psychology, industrial and organizational psychology, and organizational behaviour and ecology (e.g., Alderfer, 1987; Baron & Boudreau, 1987; Gibson, 1979; Hackman, 1976; Krahé, 1992; Schneider, 1987; Warr, 1987). From the point of view of modern interactionism, for instance, there exists situational features that can be consensually regarded as part of the situation. These features are conceptualized as situational "affordances," and are constructs that imply the complimentarity of both work environments and workers. What makes the features "quasi-objective" is the fact that they belong to the work situation irrespective of whether or not the job incumbent recognizes them as such. For example, a danger signal tells a majority of workers to run to the emergency exit. Affordances have some conceptual similarity with Hackman's (1976) "group-supplied stimuli."

Another justification is provided by Schneider's (1987) ASA framework. This framework suggests that employees will experience similar working conditions due to attraction, selection, and attrition processes in an organization. This results in similarity in behaviour within a work setting. In other words, the people make the workplace (Schneider, 1987). Although Schneider bases his framework primarily at the organizational level, it is most likely that his ideas can be employed at the group level of analysis.

The claim that group assessment (i.e., aggregated data) is more objective is corroborated by several empirical findings. For instance, a metaanalysis of 16 convergence studies conducted by Spector (1992) showed that aggregate-level correlations between job characteristics and outcomes were similar to individual level correlations. Moreover, it appeared that the convergent validity at the aggregated level was rather large, and even larger than at the individual level.

PURPOSE

The purpose of this study was to test the JD-C Model using both group and individual indicators of job characteristics. The reason why we used group and individual assessments of job demands and job autonomy is that we want to find out whether aggregated job characteristics data significantly add explained variance to individual job characteristics data with regard to employee health. In other words, the key question is whether aggregated job characteristics explain additional variance in individuals' attitudinal reactions. This could mean that some of the explained variance of employee health is attributable to some more objective features outside the individual perception or assessment (e.g., affordances or group-supplied stimuli), which has important theoretical and practical consequences. For instance, if job-related strain captures group level variance, the aspirations of the JD-C Model to be situation-centered would receive support. In addition to all this, we tried to measure the two job characteristics (job demands and job autonomy) more precisely and extensively. Lastly, the interaction effect of demands and autonomy was tested with regression techniques including a multiplicative interaction term (cf. Aiken & West, 1991; Jaccard, Turrisi, & Wan, 1990; Landsbergis et al., 1994).

We tested the JD-C Model in a single-occupation sample of health care workers because their professions are very suitable for testing the JD-C Model for several reasons (e.g., Fox, Dwyer, & Ganster, 1993; Ganster & Fusilier, 1989). First, health care workers seem to be subject to stressful work conditions (i.e., high job demands). Second, job autonomy is an important tool in present-day care delivery systems. Third, because of different types of health care areas and different specialties, health care workers are a relatively heterogeneous group. Moreover, Ganster and Fusilier (1989) showed that there is as much variability in health care samples as there is across a fairly wide range of occupations. Finally, the relative homogeneity in social class restricts the confounding effect of socioeconomic status.

In line with the JD-C Model, it is hypothesized that job demands and job autonomy have an interaction effect with respect to employee health. To be more specific, we expect that job autonomy attenuates the adverse effects of job demands on employee health. In addition to this, we will compare aggregated and individual data by means of the variance to be explained. We expect that, given that aggregated data correspond to the more objective work conditions, then, if the JD-C Model is correct, the use of aggregated data should reveal stronger interaction effects.

METHOD

Sample

A random sample of 16 institutions was drawn from all general hospitals and nursing homes in the Netherlands ($N = 218$). Eight general hospitals and eight nursing homes participated in the study. Health care workers in four units in each institute were asked to complete a questionnaire. Six types of units were present in the sample: an intensive care unit (ICU), a psychiatric unit, an internal unit, a surgical unit, a somatic unit, and, finally, a psychogeriatric unit. The initial sample consisted of 1806 health care workers from 64 units, including nurses, nurses' aides, student nurses, activity therapists, secretaries, and kitchen staff. Self-report questionnaires were filled in, and 1489 respondents returned the completed questionnaire by post (82% response). In order to keep the work situation roughly constant across individuals within a given unit, we only included health care workers with the same job level, namely, registered nurses (cf. Thomas, 1986). Furthermore, only workers who had been employed for more than 3 months were included in the final sample, in order to ensure valid and reliable observations of the work situation (cf. Frese & Zapf, 1994; Katz, 1978). These two restrictions reduce the sample to 895 registered nurses. Eighty-four percent of the respondents were women, and the age ranged from 19 to 59 years (M = 30.7, SD = 7.4). The mean work experience was 10.8 years (SD = 6.5).

Measures

Demographic variables (i.e., gender and age) functioned as control variables. These variables may confound the relationships between job characteristics and outcome variables (e.g., Karasek & Theorell, 1990; Schaufeli & Van Dierendonck, 1993; Warr, 1987). Because *type of unit* may also play a confounding role, we controlled for this variable too.

Job demands and *job autonomy* are the predictor variables. In accordance with the theoretical background, we have tried to operationalize these constructs more precisely and more completely. Therefore, these two measures differ somewhat from Karasek's measures. The two job characteristics include both individual data and aggregated data (i.e., mean group scores of the 64 units are used). This means that there are two variables for each job characteristic: one variable with individual scores and one variable with aggregated individual scores. These aggregate-level variables combine judgments across individual jobs, thus removing variance due to individual differences and idiosyncratic responses. In order to minimize bias, the subjective indicators of our two job characteristics contain items with a minimum of cognitive processing. In other words, these items are precisely defined and are as neutral as possible (cf. Frese, 1989; Frese & Zapf, 1988; Kasl, 1987; Wall et al., 1996).

Job demands were measured by an eight-item questionnaire (5-point response scale ranging from 1 = never to 5 = always). This scale was developed by De Jonge, Landeweerd, and Nijhuis (1993) and is extensively validated in Dutch samples. We used a relatively wide range of both qualitative and quantitative demanding aspects, like working under pressure of time, job complexity, working hard, and strenuous work. The reliability of this scale (Cronbach's α) is .85. An example of the items is: "In the unit where I work, work is carried out under pressure of time."

Job autonomy was measured by means of the Maastricht Autonomy Questionnaire (MAQ; De Jonge, 1995), which consists of ten Likert items with a 5-point response scale ranging from 1 = very little to 5 = very much. The MAQ measures the worker's opportunity (or freedom), inherent in the job, to determine a variety of task dimensions, like method of working, amount of work, and work goals. The reliability of the MAQ is .81. For instance, "The opportunity that the work offers to determine the method of working yourself."

In line with the two major predictions of the JD-C Model, we used four outcome variables (i.e., *emotional exhaustion*, *job-related anxiety*, *work motivation*, and *job satisfaction*).

Emotional exhaustion is a component of the Dutch version of the Maslach Burnout Inventory, the MBI-NL (Schaufeli & Van Dierendonck, 1993, 1994). Of the three dimensions of burnout, emotional exhaustion is closest to more traditional strain variables (cf. Maslach, 1993; Shirom, 1989). The scale consists of eight items, scored on a 7-point scale (ranging from 0 = never to 6 = always; $\alpha = .85$).

Job-related anxiety was measured by means of a component of the Dutch Organizational Stress Questionnaire (VOS; Reiche & Van Dijkhuizen, 1979), asking respondents how they generally felt at work. The scale consists of four items with a response scale ranging from 1 = never to 4 = always ($\alpha = .78$). The items reflect feelings of anxiety, nervousness, tenseness, and restlessness, respectively.

Work motivation was measured by five items in which the respondents were asked how interesting, stimulating, and challenging their work was (De Jonge et al., 1993). The questions were answered on a 5-point scale (response scale ranging from 1 = strongly disagree to 5 = fully agree). The reliability of this scale is .87. This scale has been well-validated in Dutch samples of health care workers (cf. De Jonge, 1995).

Job satisfaction was measured by one item: "I am satisfied with my present job." The question was answered on a 5-point scale, ranging from 1 = strongly disagree to 5 = fully agree. Several researchers have shown that a global rating of overall job satisfaction is an inclusive measure of overall job satisfaction (e.g., Scarpello & Campbell, 1983; Wanous, Reichers, & Hudy, 1997).

Data Analysis

Much behavioural and social research involves hierarchical data structures. Conventional statistical techniques (e.g., ordinary regression analysis) ignore this hierarchy and may, therefore, lead to incorrect results (Bryk & Raudenbush, 1992; Hox, 1994; Hox & Kreft, 1994).

In the multi-occupation studies regarding the JD-C Model, for example, occupational grouping was used as a measure of objective differences between jobs relevant to job redesign (e.g., Karasek & Theorell, 1990; Schwartz, Pieper, & Karasek, 1988). Although this method appears to be a slight improvement on the use of observers' ratings, it is still very conservative and too indirect to isolate the two job characteristics (Frese & Zapf, 1988; Ganster & Schaubroeck, 1991; Kasl, 1989). More specifically, information is lost if data are aggregated to mean group scores. There is a great deal of imprecision as a result of the inability to deal with variability in job characteristics *within* the group (Ganster & Fusilier, 1989; Landsbergis, Schurman, Israel, Schnall, Hugentobler, Cahill, & Baker, 1993). Consequently, the statistical analysis may lose power (Hox, 1994).

Furthermore, conventional statistical techniques lean heavily on the assumption of independence of observations. A common problem with these techniques is that the statistical dependence among the scores of employees within the same group (due to group characteristics not included in the model) is discounted. All observations are regarded as independent, when in fact there is dependence (Hox, 1994; Vancouver, Millsap, & Peters, 1994). Violation of the assumption of independence of observations may cause too small estimates of the standard errors of conventional statistical techniques (Bryk & Raudenbush, 1992). This negative bias in turn may lead to spurious "significant" findings.

A final problem is that in small groups, the group averages will have large standard errors. Conventional statistical analysis using group means will be unusable to separate systematic variation from sampling error (Vancouver et al., 1994).

Recent developments in statistical theory with regard to the estimation of hierarchical linear models allow us to take the hierarchy in data into account (Aitkin & Longford, 1986). In this so-called "multilevel research," the data structure in the population is hierarchical, and the data are viewed as a multistage sample from this hierarchical population. For example, in organizational research, the population consists of organizations, units or groups within these organizations, and employees within these units or groups. With the help of multilevel models, we can formulate and test hypotheses about relationships occurring at different levels and even across levels. In the present study, a three-level model is used (cf. Bryk & Raudenbush, 1992, Chap. 8). First, the macrolevel contains a random sample of 16 institutions. Second, there are 64 units at the mesolevel. Finally, there are 895 nurses assumed to be randomly sampled per unit (microlevel).

The basic hierarchical regression model for a three-level dataset can be formulated as a general regression equation with a dependent variable y and independent variables x_1 to x_h in which the subscript i refers to the microlevel (nurse), j to the mesolevel (unit), and k to the macrolevel (institution; see Eq. 1).

$$y_{ijk} = \beta_{0jk} + \beta_{1jk}x_{1ijk} + \beta_{2jk}x_{2ijk} + \ldots + \beta_{hjk}x_{hijk} + e_{ijk} \quad (1)$$

The subscript h indexes the independent variable x and the corresponding regression parameter β. Equation (1) is the general microlevel model. In the multilevel model, the intercept (β_{0jk}) and regression coefficients (βs) of microlevel predictors (such as gender, age, and job demands) may vary across mesolevel units (units) and across macrolevel units (institutions), randomly and/or as a linear function of a mesolevel or macrolevel fixed factor (see Bryk & Raudenbush, 1992). In our model, we assume that the intercept (β_{0jk}) from Eq. (1) can be rewritten as presented in Eq. (2):

$$b_{0jk} = b_0 + \sum_{q=1}^{5} y_{0q} z_q + u_{0jk} + v_{0k} \quad (2)$$

in which z_1 to z_5 represent the dummy variables for type of unit (mesolevel fixed factors), u_{0jk} the random effect of the factor unit within type of unit, and v_{0k} the random effect of the factor institution. In this way, differences in health and well-being between units and institutions are accommodated.

Because of the exploratory nature of this study, explicit hypotheses about the interaction between our predictor variables on the one hand, and the random factors unit and institution on the other (so-called cross-level effects) were absent. Therefore, we restricted our analyses to random variation between units and institutions in the intercept (β_{0jk}) only, which represents random (main) effects of the factors unit and institution. The other regression coefficients (β_1 to β_h) are assumed to be constant across units and institutions, which implies noninteraction between fixed factors (xs) and random factors (unit and institution).

This results in a multilevel model in which individuals are the unit of analysis, and in which the intercept β_{0jk} may vary at two levels: units and institutions. Additionally, some mesolevel and macrolevel fixed factors can be introduced to explain variability. For our purpose, we only included mesolevel fixed factors, that is, the two aggregated job characteristics and their interaction term.

Taken together, multilevel analysis has several advantages in comparison with conventional statistical techniques. First, data from more than one hierarchical level can be included in the analysis. So, with respect to the JD-C Model, we are able to estimate the relative importance of individual and group level factors. Second, the statistical dependence between individuals of the same unit (or units of the same institution) is taken into account through the random variation of β_{0jk} across units and institutions. Finally, the multilevel model separates sampling error due to variation between units from variation within units.

In this study, the multilevel models are estimated and fitted with the computer program VARCL (*VAR*iance *C*omponent analysis by maximum *L*ikelihood; Longford, 1993). VARCL is one of the most popular computer programs for analyzing multilevel regression models (cf. Hox, 1994; Kreft, De Leeuw & Van der Leeden, 1994). Additionally, a standard statistical program (SPSS) was used in order to obtain the two raw data files with aggregated and individual data, respectively, to be used in VARCL (cf. Hox, 1994).

Model Building

The strategy for model building within VARCL is to follow the hypothesis and expectations, as described earlier.

1. The first model that is fitted is an empty model: a fully unconditional model without predictors at any level apart from the random effects of units and institutions. This model represents the (unexplained) variation of the outcome variables at each level (nurse, unit and institution). In case of significant unit and institution effects, we will have to perform multilevel analyses rather than ordinary linear regression analyses.
2. The second model includes all covariates (i.e., gender, age, and type of unit) and the individual job characteristics. How much of the total variance can be explained by these variables?
3. The third model again includes the variables of model 2, but now the aggregated job characteristics are added. The questions are, first, whether the aggregated variables add explained variance to model 2, and second, how much variance can be explained by both individual and aggregated variables.

In order to test the interaction hypothesis, we performed multilevel regression analyses including a multiplicative interaction term for all outcome variables. The multiplicative term was computed from the grand mean centered scores of job demands and job autonomy, for the individual variables and aggregated variables, respectively (cf. Aiken & West, 1991; Kleinbaum, Kupper, & Muller, 1988).

RESULTS

Preliminary Analyses

The means, standard deviations, and zero-order Pearson correlations of the study variables are presented in Table I. Note that there are two covariates at the microlevel (i.e., gender and age) and five dummy variables

Table I. Means, Standard Deviations, and Zero-Order Pearson Correlations of the Study Variables ($n = 895$)

	Variable	*M*	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Gender[a]	–	–																
2	Age	30.70	7.36	−.14*															
3	Indiv. dem.	3.20	.56	.09*	−.06														
4	Indiv. aut.	2.72	.55	−.13*	.08*	−.30*													
5	Indiv. dxa.[b]	−.09	.34	.00	−.03	−.07*	.01												
6	Aggr. dem.	3.21	.32	.20*	−.08*	.56*	−.25*	−.02											
7	Aggr. auto.	2.69	.28	−.20*	.08*	−.30*	.48*	−.04	−.52*										
8	Aggr. dxa.[b]	−.04	.10	.12*	−.07*	.01	−.13*	.33*	.02	−.26*									
9	Satisfaction	3.90	.86	.09*	−.07*	−.18*	.13*	.11*	−.15*	.09*	.15*								
10	Motivation	3.80	.68	−.01	−.10*	−.09*	.20*	.10*	−.18*	.18*	.07*	.49*							
11	Exhaustion	1.74	.87	−.02	−.02	.45*	−.13*	−.05	.25*	−.08*	−.09*	−.42*	−.21*						
12	Anxiety	1.47	.43	−.04	−.01	.19*	−.01	−.06	.10*	.04	−.11*	−.25*	−.11*	.48*					
13	Psychiatric	–	–	−.26*	.18*	−.16*	.19*	−.06	−.28*	.41*	−.27*	−.17*	−.04	.10*	.16*				
14	Internal	–	–	.13*	−.06	.03	.08*	.08*	.06	.16*	.14*	.06	.06	−.02	.00	−.14*			
15	Surgical	–	–	.10*	−.03	.07*	−.02	.06	.12*	−.04	.15*	−.00	.06	.06	.01	−.14*	−.13*		
16	Somatic	–	–	.15*	−.08*	.20*	−.22*	−.11*	.35*	−.46*	−.15*	−.05	−.13*	.02	−.04	−.21*	−.20*	−.19*	
17	Psycho-ger.	–	–	.15*	−.08*	−.00	−.06	.01	−.01	−.13*	.09*	.05	−.10*	.01	−.06	−.21*	−.20*	−.19*	−.28*

[a]Gender was coded 0 (males) and 1 (females).
[b]Grand mean centered.
*$p < .05$ (two-tailed).

at the mesolevel, controlling for the six types of units. The Intensive Care Unit (ICU) is the reference category and has the value 0 on all five dummy variables. At the mesolevel, the predictor variables job demands and job autonomy consist of aggregated individual data (i.e., mean group score per unit was computed; cf. Hox, 1994).

To justify aggregation of the two job characteristics, we have to demonstrate sufficient homogeneity of within-unit variance. To test whether there was agreement within the 64 units of the ratings of job demands and job autonomy, we used the estimate of within-group interrater reliability of James, Demaree, and Wolf (1993). This coefficient can be interpreted similarly to other types of reliability coefficients, such as coefficient alpha (cf. George, 1990). In general, the average within-group interrater reliability for job demands and job autonomy was .95 and .96, respectively. In summary, the reliability estimates for the two job characteristics indicated a high level of agreement within units, justifying the use of aggregates in subsequent analyses.

Finally, a confirmatory factor analysis (LISREL 8) was conducted to show that indeed there are four separate outcome variables (cf. Jöreskog & Sörbom, 1993). The corresponding LISREL analysis showed that a four-factor solution yielded an acceptable chi-square relative to its degrees of freedom ($\chi^2(129) = 513.39$, $p < .001$), and relatively good other fit indices (NNFI = .93; CFI = .94; AGFI = .91; RMSEA = .06).

Model Tests

The first model within VARCL is an empty model with only one fixed effect, namely the intercept (the average individual mean) and two random effects of the factors units and institutions. Significance of the random effects of units and institutions within VARCL was tested by computing the deviance (*D*) for the ordinary regression model (a regression model without these random effects). The difference between this deviance and the deviance of our multilevel null model has a χ^2-distribution with two degrees of freedom under H_0 such that there are neither unit nor institution effects (e.g., Bryk & Raudenbush, 1992; Kleinbaum et al., 1988). For all outcome variables, the results showed that the difference between the two deviances is significant, which means that H_0 was rejected. We may conclude that there are differences between units and/or institutions with respect to all outcome variables. The variance in these variables is mainly a function of individual differences (85.7%–94.4%), but unit and institution differences together explain some of the variance (5.6%–14.3%). So, multilevel regression analyses rather than ordinary regression analyses have to be performed.

Table II. Results of the Multilevel Regression Analyses with Respect to Emotional Exhaustion (p-Values Based on Approximate Standard Errors Provided by VARCL)

	Model		
	1	2	3
Grand mean (β_0)	1.76	1.76	1.78
Individual level[b]			
Gender		−.10	−.09
Age		−.00	−.00
Job demands		.73*	.71*
Job autonomy		−.04	−.04
Dem. × aut.		−.02	.01
Group level[b]			
Type of unit[a]			
Psychiatric		.55*	.52*
Internal		.12	.11
Surgical		.24*	.23*
Somatic		.06	−.01
Psycho-geriatric		.20*	.17
Job demands			.10
Job autonomy			−.07
Dem. × aut.			−.65
Variance decomposition (σ_e^2)			
Individual level	.680	.561	.560
Group level	.071	.011	.010
Institution level	.013	.002	.000
Model fit			
Deviance (D)	2256.30	2040.54	2035.99
Δ model 1 (ΔD)		215.76*	
Δ model 2 (ΔD)			4.55
Δ df		10	3
R^2		24.9%	25.4%

[a]Reference category: ICU.
[b]Unstandardized regression coefficients.
*$p < .05$.

Emotional Exhaustion

The results of the multilevel regression analyses with emotional exhaustion as outcome variable are given in Table II. In the second model of Table II, all eight covariates and the two individual job characteristics are entered.

Different models can be compared with respect to predictive power by a likelihood ratio test (Bosker & Snijders, 1990; Bryk & Raudenbush, 1992). Deviance (D) is computed for each model and the difference between the deviance statistics (ΔD) is used to test the hypotheses. If one model is a special, reduced version of the other model, this difference has a χ^2-distribution under H_0 that the extended model does not predict better than the reduced model. Critical values of the χ^2-statistic mean that the reduced model is too simple a description of the data (e.g., Kleinbaum et al., 1988).

After entering the above-mentioned variables, the overall model fit improved ($\Delta D(10) = 215.76$, $p < .05$). This implies that model 2 has a better fit than model 1, and reduces unexplained variance at all three levels. The total modeled, or explained, proportion of variance (R^2) is 24.9%. For a random intercept model this parameter can be estimated as the proportional reduction in mean squared prediction error due to predictor variables (see also Snijders & Bosker, 1994).

It appears however that the interaction term of job demands and job autonomy is not significant. Only individual job demands have a significant positive relationship with emotional exhaustion. In other words, higher levels of individual job demands are associated with higher levels of emotional exhaustion.

In our next model aggregated variables are entered in order to explain differences in emotional exhaustion. Moreover, model 3 examines whether aggregated job characteristics add variance to model 2. Table II shows that this model does *not* have a better fit than model 2 ($\Delta D(3) = 4.55$, $p =$ n.s.), indicating that the effects of the aggregated variables are modest. The total modeled variance is 25.4%.

Job-Related Anxiety

Table III presents the results of the multilevel regression analyses with job-related anxiety as outcome variable. Model 2 contains the results for the covariates and the individual job characteristics. Entering these variables improved model fit ($\Delta D(10) = 63.03$, $p < .05$) and reduced some unexplained variance at the individual and group level (modelled variance: 8.5%). The table indicates that the interaction term of job demands and job autonomy is not significant. Similar to emotional exhaustion, model 2 shows that the individual job demands have a significant positive association with anxiety. That is, higher levels of individual job demands are related to higher levels of job-related anxiety.

The aggregated variables were entered in the next model (model 3). Compared with model 2, model 3 does *not* lead to an improvement in model fit ($\Delta D(3) = 6.07$, $p =$ n.s.). This means that the remaining unexplained variance in model 2 cannot be explained by the aggregated job characteristics. The total modeled variance in model 3 is 9.1%.

Work Motivation

The results of the multilevel regression analyses with work motivation are presented in Table IV. Entering the covariates and individual variables in model 2 improved model fit ($\Delta D(10) = 58.91$, $p < .05$). So, these vari-

Table III. Results of the Multilevel Regression Analyses with Respect to Job Related Anxiety (p-Values Based on Approximate Standard Errors Provided by VARCL)

	Model		
	1	2	3
Grand mean (β_0)	1.47	1.54	1.55
Individual level[b]			
Gender		−.01	−.01
Age		−.00	−.00
Job demands		.18*	.15*
Job autonomy		.01	.00
Dem. × aut.		−.05	−.03
Group level[b]			
Type of unit[a]			
Psychiatric		.23*	.22*
Internal		.00	−.01
Surgical		.00	−.01
Somatic		−.06	−.09
Psycho-geriatric		−.04	−.05
Job demands			.10
Job autonomy			.01
Dem. × aut.			−.28
Variance decomposition (σ_e^2)			
Individual level	.178	.173	.172
Group level	.011	.000	.000
Institution level	.000	.000	.000
Model fit			
Deviance (D)	1031.60	968.57	962.50
Δ model 1 (ΔD)		63.03*	
Δ model 2 (ΔD)			6.07
Δ df		10	3
R^2		8.6%	9.1%

[a]Reference category: ICU.
[b]Unstandardized regression coefficients.
*$p < .05$.

ables contribute significantly to the explanation of work motivation at all three levels: the entire modeled variance is 10.6%.

Model 3 provides a significant improvement in model fit compared with model 2 ($\Delta D(3) = 11.71$, $p < .05$). The aggregated variables are able to explain some variance that cannot be explained by the individual variables. The total modeled variance is 12.8%. Finally, this model shows a significant positive interaction effect at the individual level. Added to this, the aggregated job demands have a significant negative relationship with work motivation. In other words, higher levels of aggregated job demands are associated with lower levels of work motivation.

The technique for examining the interaction between job demands and job autonomy is plotting the equations (cf. Aiken & West, 1991). Following

Table IV. Results of the Multilevel Regression Analyses with Respect to Work Motivation (p-Values Based on Approximate Standard Errors Provided by VARCL)

	Model		
	1	2	3
Grand mean (β_0)	3.77	4.31	4.25
Individual level[b]			
Gender		.10	.10
Age		−.01	−.01
Job demands		.02	.07
Job autonomy		.21*	.20*
Dem. × aut.		.14*	.13*
Group level[b]			
Type of unit[a]			
Psychiatric		−.31*	−.32*
Internal		−.20	−.16
Surgical		−.16	−.08
Somatic		−.40*	−.24*
Psycho-geriatric		−.41*	−.34*
Job demands			−.31*
Job autonomy			.19
Dem. × aut.			.36
Variance decomposition (σ_e^2)			
Individual level	.403	.386	.385
Group level	.046	.034	.025
Institution level	.021	.000	.000
Model fit			
Deviance (D)	1796.80	1737.89	1726.18
Δ model 1 (ΔD)		58.91*	
Δ model 2 (ΔD)			11.71*
Δ df		10	3
R^2		10.6%	12.8%

[a]Reference category: ICU.
[b]Unstandardized regression coefficients.
$*p < .05$.

the method of Cohen and Cohen (1983), values of the predictor variables were chosen one standard deviation below and above the mean. Simple regression lines were then generated by entering these values in the regression equation. The results of the computations of these simple regression equations are given in Fig. 1.

The interaction term at individual level with regard to work motivation shows that job demands and work motivation are slightly positively related at *high* levels of autonomy. At the same time, however, demands and motivation are slightly negatively associated in the case of *low* levels of autonomy.

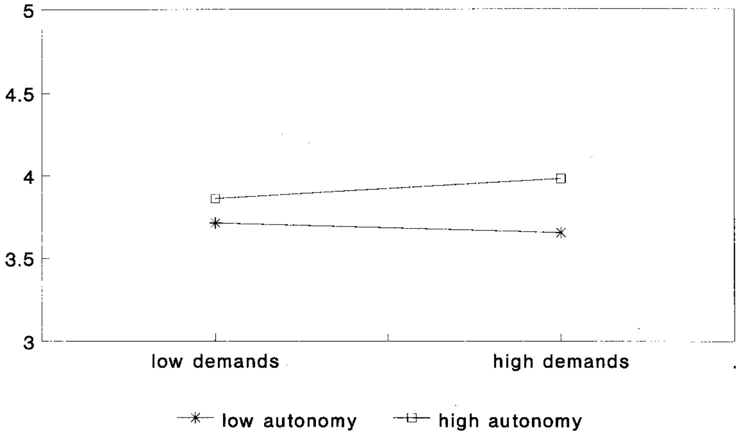

Fig. 1. Graphical representation of the individual level interaction among job demands and job autonomy in the prediction of work motivation.

Job Satisfaction

Finally, Table V shows the results of the multilevel regression analyses with job satisfaction. First, the model fit improved significantly when the covariates and individual variables are entered in the model ($\Delta D(10) = 61.12$, $p < .05$). The modeled variance is 10.4%. Next, model 3 includes the three aggregated variables, and shows a significant improvement in model fit ($\Delta D(3) = 12.14$, $p < .05$). Model 3 reduced unexplained variance particularly at group and institution level; the total explained variance is 13.2%. Lastly, this model shows a significant positive interaction effect at the group level. Job demands and job autonomy at individual level have a significant negative and positive association with job satisfaction, respectively. That is, higher levels of individual job demands are related to lower levels of job satisfaction. Conversely, higher levels of job autonomy are associated with higher levels of job satisfaction.

Figure 2 shows the graphical representation of the interaction between job demands and job autonomy at group level with regard to job satisfaction. It appears that job demands and job satisfaction are positively associated in the case of *high* levels of job autonomy. At *low* levels of job autonomy, however, job demands and job satisfaction are negatively related.

In multilevel literature, our aggregated variables are considered to be *contextual effects* (Bosker & Snijders, 1991; Raudenbush, 1989). The classic formulation of a contextual effect model involves a regression equation including both the individual variable(s) and the group variable(s). However,

Table V. Results of the Multilevel Regression Analyses with Respect to Job Satisfaction (*p*-Values Based on Approximate Standard Errors Provided by VARCL)

	Model		
	1	2	3
Grand mean (β_0)	3.88	3.96	3.93
Individual level[b]			
Gender		.23*	.22*
Age		−.00	−.00
Job demands		−.22*	−.18*
Job autonomy		.16*	.15*
Dem. × aut.		.15	.12
Group level[b]			
Type of unit[a]			
Psychiatric		−.54*	−.53*
Internal		−.05	−.05
Surgical		−.15	−.09
Somatic		−.17	.04
Psycho-geriatric		−.12	−.03
Job demands			−.22
Job autonomy			.35
Dem. × aut.			1.12*
Variance decomposition (σ_e^2)			
Individual level	.628	.604	.602
Group level	.085	.035	.028
Institution level	.024	.021	.010
Model fit			
Deviance (*D*)	2197.32	2136.20	2124.06
Δ model 1 (Δ*D*)		61.12*	
Δ model 2 (Δ*D*)			12.14*
Δ *df*		10	3
R^2		10.4%	13.2%

[a]Reference category: ICU.
[b]Unstandardized regression coefficients.
$*p < .05$.

such a model might suffer from high collinearity, leading to poor precision in model fit (Aitkin & Longford, 1986).

Our models 3 (Tables II–V) are such contextual effect models. To test whether the models are subject to high collinearity, we carried out ordinary regression analyses of model 3 with all four outcome variables. Collinearity was checked by means of the Variance Inflation Factor (VIF). A rule of thumb for evaluating VIFs is that one should be concerned about any value larger than 10.0 (Kleinbaum et al., 1988). The VIFs in our analyses did not exceed 3.3, which indicates that no severe collinearity problems are to be expected. All in all, it can be concluded that our contextual effect models do not suffer from high collinearity.

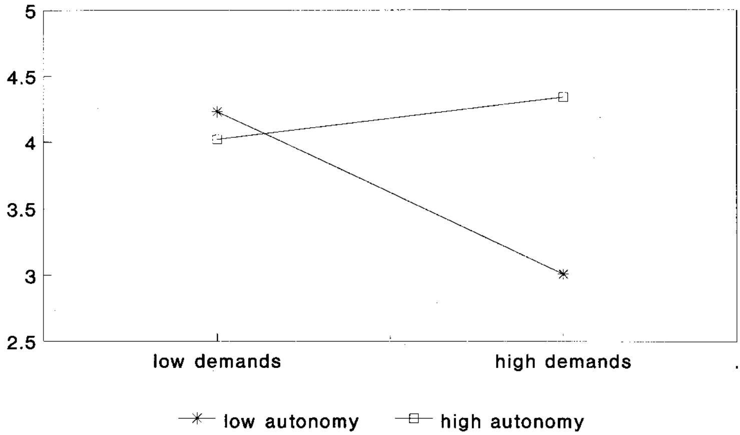

Fig. 2. Graphical representation of the group level interaction among job demands and job autonomy in the prediction of job satisfaction.

DISCUSSION

The present study contributes to job redesign and job stress research by testing the Job Demand-Control Model using a multilevel analytic approach. To be more specific, we used both aggregated individual data and individual data as indicators of the job characteristics job demands and job autonomy. In our view, the aggregated data correspond to the more objective work conditions, while the individual data correspond to stressor perceptions or results of appraisal processes. In interpreting the findings of this study, it is important to consider not only the confirmation of the hypothesis and the answers on the questions, but also their relative significance. We will briefly discuss them.

First, the results partly support the interaction hypothesis of the JD-C Model by finding two interaction effects, and both in the expected direction. The significant interaction terms represent 25% of the interactions tested, which means no strong support for the JD-C Model. The support for the model is quite meaningful, however, because one significant strong interaction was found at the aggregated (i.e., group) level. This finding underlines the position of the JD-C Model as a situation-centered model with the interplay of two more objective job characteristics.

In contrast, *no* significant interaction effects were found for the adverse health outcomes. Although the interaction terms were in the right direction, the level of 5% significance just could not be reached (p-values were about .06 and .07). An explanation for this unexpected result may be some lack of power in this kind of outcome variables, and in detecting interactions at all (cf. Aiken & West, 1991).

The modeled variance (R^2) for the best fitting models ranged from 9% for job-related anxiety to 25% for emotional exhaustion. Added to this, the job characteristics account for a higher amount of *reduced* variance in adverse health outcomes (exhaustion: 9%, and anxiety: 5%) than in the two other variables (i.e., about 2% for both motivation and satisfaction). Although these values are not very high, they are rather consistent with those obtained by other high quality occupational stress studies (e.g., Karasek, 1989; Semmer et al., 1996; Warr, 1990).

Second, an important question was whether aggregated job characteristics data significantly add explained variance to individual job characteristics data with respect to employee health. Though the percentages are not very high, the findings indicate that aggregated job characteristics data are important in explaining work motivation and job satisfaction, and are able to explain some variance that could not be explained by the individual data (about 2–3%). From the standpoint of measurement, one can argue that there are things which can be measured better by aggregated level characteristics. This remarkable point has also been noted by Zapf (1989). For instance, job incumbents may be so used to their work situation in such a way that they deny some of the occupational hazards. In other words, group level characteristics may tap (a part of) the context in which individual workers operate. These results legitimate the claim of the JD-C Model to be a environmental-oriented model as far as work motivation and job satisfaction are concerned.

Conversely, the aggregated job characteristics were not important in explaining emotional exhaustion and job-related anxiety while addressing the individual level job characteristics. Moreover, they did not significantly add explained variance to individual job characteristics. An explanation may be that emotional exhaustion and job-related anxiety are for the most part determined by stressor perceptions or results of appraisal processes (cf. Lazarus, 1995). Another explanation may be that other factors (e.g., social cues, method variance) must be acknowledged as potential sources (cf. Spector, 1992). So, based upon these findings, Karasek's JD-C Model seems to be not only situation-centered, but also contains some person-centered assumptions. In summary, the current findings suggest that work motivation and job satisfaction are more dependent on the group (i.e., the average worker), while emotional exhaustion and, to a lesser extent anxiety, are more dependent on the individual.

An interesting explanation for the group level and individual level effects may be that both group and individual assessment (partly) reflect the same features of the work situation, which were referred to as affordances (see introduction). Affordances seem to be important for all workers, because they can be regarded as being part of the situation. Another theoretical rationale for these effects has been provided by an intergroup theory (cf. Alderfer, 1987; Schneider, 1985). The logic of this theory is that interactions of employees at any level of analysis represent the effects of group memberships. In its most expanded form, this perspective emphasizes the embedded nature of subsystems. In other words, every person can be embedded in a group (an employee in a unit), every group can be embedded in other groups (a unit in an organization), and so on. Applied to our study, employee health might be a product of multilevel embeddedness of job characteristics. That is, the individual level of analysis is embedded in, and affected by, at least the next level of analysis. So, it seems that the next larger unit(s) in which individual job characteristics are embedded will also have an impact, at least on work motivation and job satisfaction.

All in all, the present study supports the choice of the JD-C Model in job redesign research as well as job stress research. It can be concluded that perceptions of job characteristics do not only reflect subjective feelings, but also are grounded in some kind of environmental reality, as far as job satisfaction and work motivation are concerned. Assuming that aggregated job characteristics data are more related to the objective work environment than individual data, these results suggest a redesign of work conditions for the sake of job satisfaction and work motivation and a change of the individual worker for the sake of emotional exhaustion and job-related anxiety.

Some weaknesses of the present study can be mentioned. First, we tried to define nearly identical jobs in order to meet the criterion of the same work situations. However, our method of sample restriction (i.e., 895 registered nurses left) probably led to a reduction in variance. Despite the fact that our procedure was variance reducing, we did find some evidence for the interactive JD-C Model. Second, as noted before, aggregated data are more reliable than individual data and thus less affected by attenuation. However, aggregated data will have this benefit only in case of high unsystematic error variance. In case of low error variance, "real" differences between individuals within units will be ignored using the method of aggregation. Third, our present multilevel analysis is not totally free of problems. For example, it can only be applied to each outcome variable separately, and consequently ignores relationships between them. Multivariate extensions, like multilevel structural equation modeling, are needed (e.g., Hox, 1994; McArdle & Hamagami, 1996; Muthén, 1994). Fourth, we used an exploratory procedure to derive a parsimonious model. So, there is a possibility that some decisions we have made are based on chance. The current findings have to be cross-validated with another large and hierarchical sample. Finally, it is not possible to determine whether the assumed causal paths are present on the basis of our cross-sectional data. Although JD-C theory guided our hypothesis about causal relationships, hypothesized causal connections should be interpreted carefully. For this purpose, longitudinal studies are required (cf. Zapf, Dormann & Frese, 1996).

In conclusion, this study shows that both group and individual assessments of job characteristics are important in predicting employee health. Practically, our results support the notion that researchers may need to focus on work conditions (i.e., the concept of the ideal typical worker) and the individual employee simultaneously. Furthermore, the results imply that previous individual level research should be supplemented by a consideration of aggregated level effects. Further research, however, is needed for a better understanding of the relationships that were hypothesized and investigated, and for refinements of techniques and measurements.

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