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Occupational stress in (inter)action: the interplay between job demands and job resources

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Summary The present study addresses theoretical issues involving different interaction effects between job demands and job resources, accompanied by a thorough empirical test of interaction terms in the demand–control (DC) model and the effort–reward imbalance (ERI) model in relation to employee health and well-being (i.e., exhaustion, psychosomatic health complaints, company-registered sickness absence). Neither the DC model nor the ERI model gives a clear theoretical rationale or preference for a particular interaction term. Hierarchical regression analyses were conducted among 405 nursing home employees and cross-validated in a comparable sample ($N = 471$). Results including cross-validation showed that only a multiplicative interaction term yielded consistent results for both the DC model and the ERI model. Theoretical as well as empirical results argue for a multiplicative interaction term to test the DC model and the ERI model. Future job stress research may benefit from the idea that there should be a theoretical preference for any interaction form, either in the DC model or in the ERI model. However, more research on interactions is needed to address this topic adequately. Copyright © 2005 John Wiley & Sons, Ltd.

Introduction

Over the past decades, occupational stress and health research has been guided by theoretical models (see Cooper, 1998). Those work stress models have proven to be useful, as they help to identify particular job characteristics important for employee well-being. Two important models in work stress research are: (1) the demand–control (DC) model (Karasek, 1979; Karasek & Theorell, 1990; Theorell & Karasek, 1996); and (2) the effort–reward imbalance (ERI) model (Siegrist, 1996, 1998; Siegrist, Siegrist, & Weber, 1986). The DC model predicts that the most adverse health effects of psychological strain occur when job demands are high and decision latitude is low. This particular combination of job characteristics is termed 'job strain' or a 'high strain job.' A second assumption is that active learning

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behavior, motivation, and personal growth occur when both job demands and decision latitude are high. The ERI model assumes that emotional distress and adverse health effects occur when there is an imbalance between (high) efforts and (low) occupational rewards—what is called a disturbed process of social exchange. Furthermore, the model predicts that employees characterized by a motivational pattern of excessive work-related overcommitment have an elevated risk for experiencing this stressful imbalance, which may lead to more health complaints (Peter, 2002; Peter et al., 1998).

A central tenet of both models is an *interaction* between, on the one hand, job demands that are placed upon the employee (i.e., psychological job demands termed by Karasek and job-related efforts termed by Siegrist), and, on the other hand, job-related resources (such as job decision latitude and occupational rewards) to cope with such requirements. In this way, both models can be seen as balance models, in which job demands can be generally defined as those aspects of the job which require additional/sustained physical, psychological, or emotional effort (De Jonge & Dormann, 2003). Demands are not necessarily negative; they can also be positive in the right circumstances (see Warr, 1987). Job resources can be generally described as those aspects of the job which can lead to buffering job demands and related efforts (e.g., Karasek, 1979; Schaufeli & Bakker, 2004).

Although the interaction is a central feature of both models, this subject has been surrounded by diverse meanings and interpretations. First of all, questions can be pointed towards the meaning of an interaction as such. What exactly is an interaction between job demands and job resources? Should we refer to an interaction in the case of an 'additive' effect (e.g., just combining high demands and low resources), or should there be also a 'buffer' effect (e.g., high resources prevent variations in demands from increasing the risk of illness, and the risk due to demands will be apparent only when resources are low; see Kasl, 1996), or even a 'synergistic' effect (e.g., both high demands and low resources are associated with increased risk but combining those two increases the risk beyond mere additive effects; see Kasl, 1996)? Second, looking in more detail at the two models, what do they say about an interaction per se (or the relation between the main variables)? Third, what takes place in empirical research? How do researchers testing the model(s) operationalize the interaction?

In order to gain more insight into the genesis of the interaction between job demands and job resources, we first concentrate on the classification of interaction terms according to Edwards and Cooper (1990) into three fundamentally different interaction forms. Next, we give an overview of successively the DC model and the ERI model in relation to interactions, before testing different interaction terms in both models empirically.

More concretely, the aim of the present study is twofold: (1) to give a theoretical overview of interaction terms, and to relate these interaction terms to both the DC model and the ERI model based on the literature; (2) to provide an empirical test in two separate samples using three fundamentally different interaction terms to illustrate the impact of different interactions between demands and resources on employee well-being.

Classification of interactions

Reviewing the literature with regard to the DC model and the ERI model shows that many different interaction terms have been used to display the relation between job demands and job resources on the one hand, and strain reactions on the other hand. To show that different ways of classifying interactions do indeed have different consequences for the form and (statistical) content of the interaction, Edwards and Cooper (1990) graphically displayed and explained three fundamentally different interaction terms: the discrepancy, the interactive, and the proportional form (see Figure 1).

Firstly, the *discrepancy* term reflects a positive relation between job demands and strain, and a negative relation between job resources and strain (cf. Edwards & Cooper, 1990). Actually, this effect is

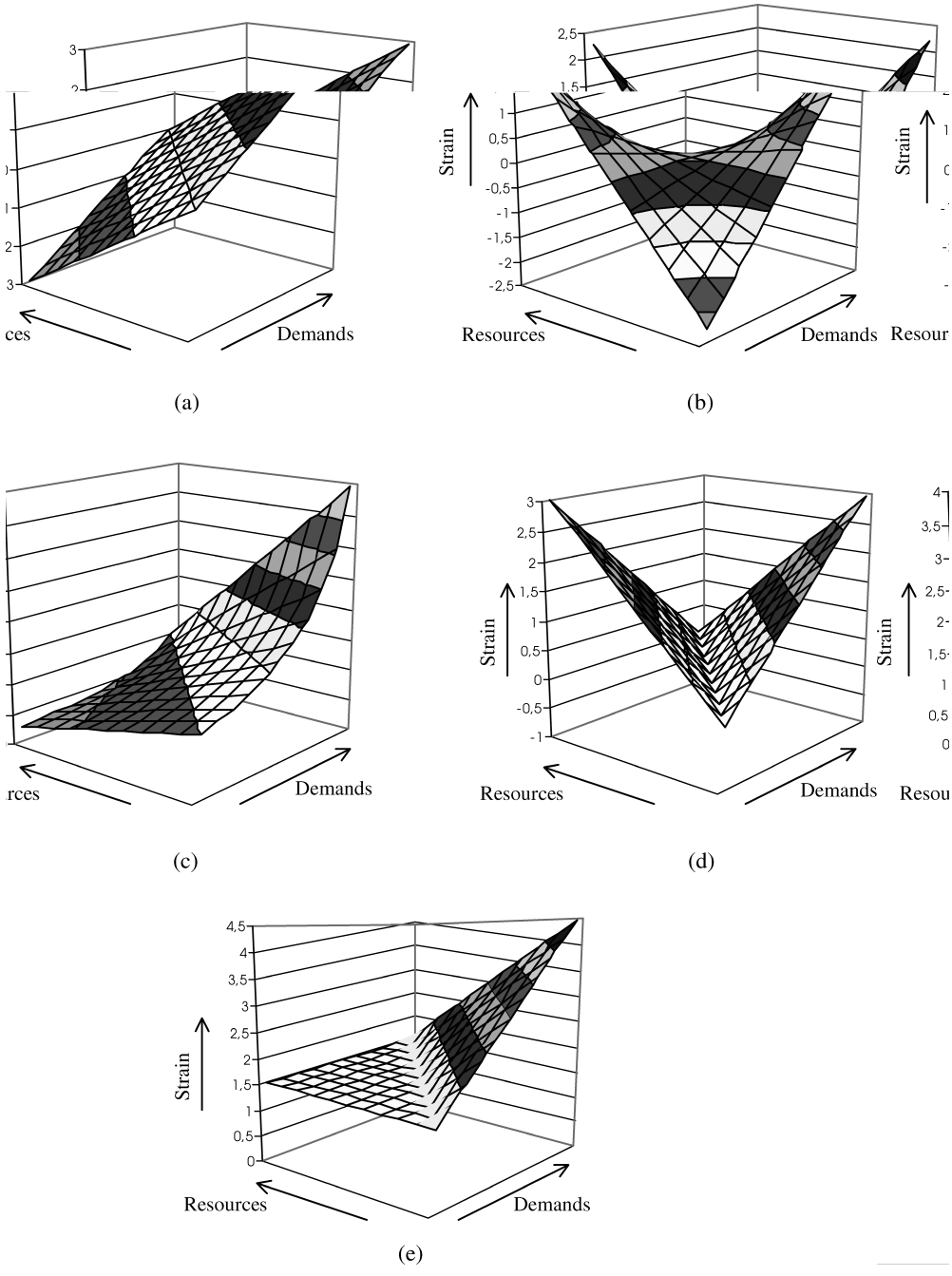

Figure 1. Functional forms relating demands, resources, and strain (see Edwards & Cooper, 1990; Edwards & Van Harrison, 1993): (a) discrepancy; (b) multiplicative; (c) ratio; (d) absolute value; (e) relative excess

similar to an additive effect: each variable, demands and resources, has a linear association with strain. Demands represent a standard by which resources are compared, such that larger deviations of resources from demands are associated with strain. More concretely, this means that most strain is experienced when demands are high, especially when the amount of resources available to the

is equal to the absolute value of demands minus decision latitude plus a constant. Actually, the relative excess term bears resemblance to the absolute difference term (see Figure 1), which is the absolute value of the discrepancy term. Hence, strain is minimized when demands and resources are equivalent (see the V-shaped form). By adding a constant, which serves as a correction factor to give more empha-

relation to blood pressure. All terms revealed significant effects for systolic blood pressure, but not for diastolic blood pressure (the multiplicative and linear terms were not significant). A few other studies that tested different interaction terms simultaneously within the DC model showed different results. Karasek himself (1979) found support for relative excess as well as multiplicative interactions with regard to job and life dissatisfaction. However, Sauter (1989) noted that only the relative excess term (and not the multiplicative term) reached statistical significance for dissatisfaction and illness symptoms. As such, these studies do not seem to provide a unanimous preference for one interaction term.

Effort–reward interaction: overview

The ERI model maintains that the combination of high efforts and low rewards will have the most adverse health effects, especially among highly overcommited employees. To our knowledge, the word 'interaction' as such has been mentioned once by Siegrist and colleagues (1990) to describe a mismatch between high effort and low reward. For a long period, this combined effect was not crystallized into a specific ERI interaction effect. However, recently, Siegrist (2002) has maintained that the effect of the ratio is more than the main effects of effort and reward, which could be interpreted as a synergistic interaction effect (see Kasl, 1996). With regard to overcommitment, the model anticipates the highest risks of reduced health for people who are characterized by both effort–reward imbalance and overcommitment. It was not until very recently that the nature of the relation between effort–reward imbalance and overcommitment was clearly specified. In a recent paper, Peter (2002) states that overcommitment can have both a direct effect on employee health, and can modify the relation between effort–reward and employee health (e.g., overcommitment acting as an effect modifier).

Contrary to the theoretical description of the interaction, the *operationalization* of the ERI interaction has been more thoroughly developed. In their first manual of the effort–reward imbalance questionnaire, Siegrist and Peter (1996) suggest a ratio term to operationalize the interactive relationship between effort and reward. Thus, they assume that most strain will result from a high effort–low reward condition. Rewards will influence the relation between effort and strain considerably when rewards are low; when rewards are high (or moderate) the amount of strain is merely determined by efforts. As such, it is quite similar to a relative excess term.

The empirical literature is very consistent in testing the ERI model, both with regard to the ERI interaction term and analytical methods (for an overview see Van Vegchel, De Jonge, Bosma, & Schaufeli, 2005). Most studies tested the relation between effort and reward with a ratio term, perhaps because of the ERI questionnaire's manual. The association between effort and reward has also been tested by creating independent groups either by tertiles or by median splits. In addition, the majority of studies analyze effort–reward imbalance with the help of logistic regression analyses. There are only a few exceptions that test general linear models, such as multivariate analyses of variance (Bakker, Killmer, Siegrist, & Schaufeli, 2000; Vrijkotte, Van Doornen, & De Geus, 1999) and linear regression analyses (Calnan, Wainwright, & Almond, 2000).

Most ERI studies report an elevated risk due to the combination of high effort and low reward (see Van Vegchel et al., 2005). However, as Belkiç and colleagues (2000) have noted, in some studies a synergistic (or at least moderated) interaction seems to exist, that is, the relative risk of poor health in the case of a combined measure of high effort–low reward is substantially greater than the sum of the risks due to those two components separately (e.g., Peter & Siegrist, 1997; Siegrist, 1996). However, those interactions were not statistically tested. Since the model was merely tested with a combined high effort–low reward variable, it was not possible to test the existence of an interaction. Therefore, ERI studies do show additive effects, but whether interaction effects are present remains to be seen.

The use of hierarchical multiple regression analyses should give a better insight into which variables contribute to the interaction effect (see Kasl, 1996). Moreover, by means of regression analyses it is possible to determine whether an interaction effect is significant over and above the main effects. And finally, regression analyses allow for a comparison between different interaction terms in terms of explained variance. For those reasons, the present study will use hierarchical multiple regression analyses to calculate the different interaction terms within the DC model and the ERI model.

Viewing the DC and ERI interactions in the light of the basic interaction forms (see Edwards & Cooper, 1990) shows that different interaction terms do have different meanings and interpretations. Therefore, the choice of an interaction term should ideally be guided by theoretical assumptions. However, neither the DC model nor the ERI model gives a clear theoretical preference for one interaction term. In this paper, the main DC and ERI interactions (i.e., a subtractive, an interactive, and a proportional form) will be empirically tested to see whether different interaction terms show congruent results with regard to employee health. To relate as closely as possible to the original concepts as meant by both models (see Beehr, Glaser, Canali, & Wallwey, 2001) and to facilitate comparison with other studies (see Schnall et al., 1994), the original scales belonging to the DC model and the ERI model will be used. Since both models will be regarded as balance models, only job demands and job resources will be considered (i.e., leaving out overcommitment, which is a personal characteristic). Two samples used in the present study will contain employees from the health care sector, as they seem to be a suitable group for testing work stress models (Fox, Dwyer, & Ganster, 1993; Ganster, Fox, & Dwyer, 2001). The use of these two samples allows for cross-validation as well. In addition, both self-reported outcome variables (e.g., exhaustion, and psychosomatic health complaints) and more objective outcome variables (e.g., sickness absence duration and frequency) will be used to test the models and the corresponding interaction terms.

Organizational Context

Mission of Nursing Homes

The mission of nursing homes is to take care of elderly people, to help them in their daily living tasks, and to improve the quality of their lives. Due to high workloads nurses and nurses' aides feel that they are only able to do the most urgent things (such as feeding and medication), and that there is little room for the social aspects (such as having a chat with the inhabitants). Therefore, many nursing home employees feel they are not able to contribute to the improvement of the quality of life of the elderly.

Nursing Homes and their Work Conditions in The Netherlands

Several developments in the Netherlands have contributed to increased work stress in nursing homes. On the one hand, due to increasing life expectancies accompanied by a proportional increase in the ageing population, more people are getting older (associated with geriatric health problems). On the other hand, cost containment programs restrict the budgets staff have available. Hence, increased demand for care in combination with reduced budgets has led to sharpened criteria for admission to nursing homes, and in turn to increasingly severe health problems among those who are admitted for care. During the period this research was conducted (2000–2001), many of the participating nursing homes were facing a shortage of nurses. In practice, this meant that more work had to be done by the same number of employees, which in general led to longer working hours and more stressful working conditions, accompanied by more health problems. In conclusion,

Method

Procedure and participants

Participants of Study 1 were part of a Dutch care foundation containing six different nursing homes. Out of 554, 405 employees of the nursing homes filled out the self-report questionnaires, which is a response rate of 73 per cent. All questionnaires contained an administration number for linking the questionnaire data to the sickness absence figures. For reasons of confidentiality, tio.8(to)-419.7(th.)]TJ0 -1

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average, respondents worked 26 hours a week (SD = 8.5), and 54.2 per cent worked regular hours and 45.8 per cent variable hours.

Measures

Control variables

Age, sex, and education were included as control variables because they have been identified as possible confounders of the relation between job characteristics and outcome variables (e.g., Schaufeli &

Considering that those measures were not self-reported by the respondents, those measures can be regarded as more objective measures.

Statistical design

The following three interaction models were tested. Firstly, a discrepancy form, or the relative excess interaction, was tested which was composed of a subtractive term (|demand − decision latitude + constant|), where the constant was empirically defined at 1.5 by Karasek (1979) to place three-quarters of the sample in the category where too many demands make the absolute value expression positive, and one quarter in the category where an excess of decision latitude makes the expression positive. Secondly, a multiplicative interaction was tested, which consists of an interactive form, i.e. demands ∗ decision latitude. And finally, a ratio term was tested, which is equal to a proportional form (i.e. demands/decision latitude). Obviously, for the ERI model the interaction terms are similar apart from the concepts (i.e., substitute demands by efforts, and decision latitude by rewards, respectively), with the exception of the ratio. The ratio term for the ERI model was calculated following the guidelines of Siegrist and Peter (1996) with the help of dichotomized items and the formula: effort/(reward ∗ correction factor). The correction factor (6/11) was used to compensate for the unequal number of items in the efforts and rewards scales.

As recommended by several authors the interactions will be tested with the help of hierarchical multiple regression analyses (see Aiken & West, 1991). The hierarchical multiple regression analyses were performed with forced entry of the variables. In Step 1 the control variables were entered (i.e., age, sex, and education). Step 2 contained the independent variables, that is, demand and decision latitude for the DC model, and effort and reward for the ERI model. Finally, in Step 3 the respective interaction term (i.e., multiplicative, relative excess, or ratio) was entered for each outcome variable. Note that the three different interaction terms for the DC model and the three interaction terms for the ERI model were entered in three *separate* regression analyses, respectively. With the help of an incremental F-test (F_{inc}: Jaccard, Turrisi, & Wan, 1990), we tested whether an interaction term (Step 3) significantly explained variance over and above the variance explained by the independent variables in an additive way (Step 2). F_{inc} is the indicator of this contribution and is provided with an accompanying p-value.

The analyses used centered job characteristics (i.e., mean subtraction) to reduce potential problems of multicollinearity. Unstandardized regression coefficients are presented in the tables accordingly (Aiken & West, 1991; Jaccard et al., 1990). In addition, it should be noted that a significance level of 10 per cent was used. A general problem of interactions within regression analyses is a shortage of power (see Aiken & West, 1991; Frese, 1999), owing to which important effects can be missed.

By cross-validating the results in a different, comparable study, the reliability of regression models will be assessed. According to Kleinbaum, Kupper, and Muller (1988) the most compelling way to assess the reliability of a chosen model is to conduct a new study and test the fit of the chosen model to the new data, in which the coefficients obtained from one sample are used to predict the criterion in another sample. As an indicator Kleinbaum et al. (1988) suggest examining the 'shrinkage on cross-validation,' i.e. the difference between the R^2 for sample 1 and the R^2 for sample 2 (the last one being predicted by the coefficients of Study 1). As a rule of the thumb, the results are indicative of a reliable model when the shrinkage value is less than 0.100 (Kleinbaum et al., 1988). Moreover, the patterns of the regression coefficients from both samples were compared by subgroup analyses. Regression coefficients (for main variables and for interaction terms) were tested to see if they differed significantly based on a dummy 'sample' (i.e., Study 1 = 1, and Study 2 = 0). If the regression coefficients including the variable 'sample' were significant, this would mean that samples differed on the

specific regression coefficient, whereas a non-significant coefficient would indicate that the samples did not differ significantly.

Results

The raw data were examined prior to the hierarchical regression analyses. First examinations revealed that the distribution of duration of sickness absence was positively skewed in both studies (i.e., skewness = 2.87 in Study 1 and 3.95 in Study 2, respectively). This means there were many low scores (i.e., 0), which is usual for sickness absence duration (De Jonge et al., 2000). To normalize the data distribution as much as possible, the scores on sickness absence duration were square-rooted. After the transformation the data were approximately normally distributed (i.e., skewness = 1.51 and 1.60 for Study 1 and Study 2, respectively).

In addition, the means, standard deviations, coefficient alphas and Pearson correlations were calculated for both Study 1 and Study 2. Table 1 shows in general that the means and standard deviations from Study 1 were comparable to the means from Study 2. The reliability coefficients (Cronbach's alpha) for Study 1 were all higher than 0.70 (which is reasonably good), and most reliability coefficients for Study 2 were equal to or higher than 0.65 (which is acceptable), with the exception of demands and effort. Overall, the reliability coefficients were slightly higher for Study 1 compared to Study 2. Furthermore, Table 1 shows the correlations between the job characteristics and the outcome variables both for Study 1 (left-lower corner) and Study 2 (right-upper corner). Apart from the non-significant correlations between demands and sickness absence frequency (both studies) and between demands and sickness absence duration (Study 1), the correlations were all in the expected directions. That is, demands and efforts were positively associated with all outcome variables, whereas decision latitude and reward showed an inverse relationship with the outcome variables. Demands and

Table 1. Means, standard deviations, and Pearson correlations for Study 1 ($n = 405$) left-lower corner, and for Study 2 ($n = 471$) right-upper corner

	M_1	SD_1	M_2	SD_2	1	2	3	4	5	6	7	8
1. Job demands	2.62	0.45	2.58	0.56		−0.01	0.52**	−0.35**	0.34**	0.25**	0.07	0.12*
2. Decision latitude	2.91	0.39	2.94	0.46	−0.04		−0.07	0.07	−0.10*	−0.17**	−0.03	−0.03
3. Effort	2.03	0.59	1.93	0.66	0.58**	−0.02		−0.53**	0.61**	0.43**	0.20**	0.22**
4. Reward	3.54	0.47	3.67	0.50	−0.29**	0.22**	−0.42**		−0.48**	−0.34**	−0.14**	−0.20**
5. Emotional exhaustion	1.45	1.01	1.53	1.19	0.18**	−0.14**	0.38**	−0.41**		0.65**	0.23**	0.23**
6. Psychosomatic complaints	4.33	2.95	4.67	3.16	0.11*	−0.15**	0.22**	−0.26**	0.62**		0.24**	0.21**
7. Sickness absence—frequency	1.50	1.69	1.18	1.40	0.07	−0.13**	0.22**	−0.24**	0.24**	0.23**		0.59**
8. Sickness absence—duration	3.56	4.52	2.77	3.42	0.06	−0.19**	0.18**	−0.26**	0.30**	0.26**	0.72**	

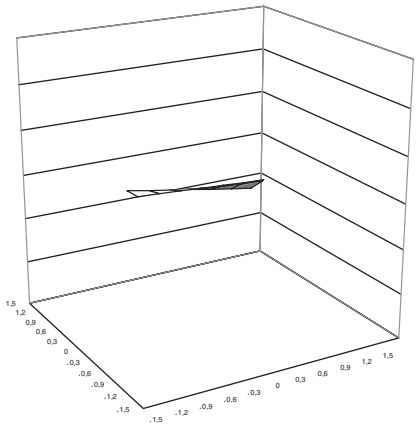
*Correlation significant at 0.05 level (2-tailed); **Correlation significant at 0.01 level (2-tailed).

effort were, as expected, highly correlated (0.58 in Study 1 and 0.52 in Study 2), which indicates that the constructs partly overlap.

To test the effects of the different interaction terms (i.e., multiplicative, relative excess, and ratio), multiple hierarchical regression analyses were conducted for various health outcomes (i.e., exhaustion, psychosomatic complaints, and sickness absence, both frequency and duration) for the DC model and

Table 2. Hierarchical multiple regression analyses of self-reported health (Study 1; $n = 350$ due to listwise deletion)

	Exhaustion		Psychosomatic health complaints	
	DC model	ERI model	DC model	ERI model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0
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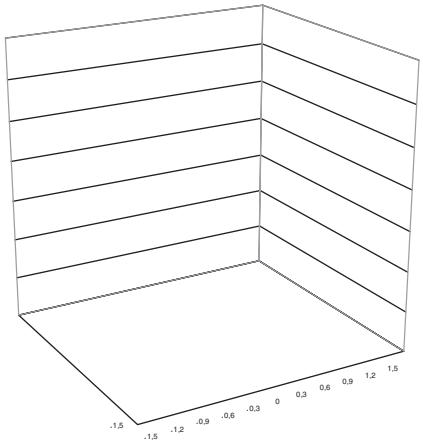
above the main effects. This interaction is displayed in Figure 6, showing that employees with high effort and low reward called in sick most often. In all other conditions (i.e., high effort–high reward, low effort–high reward, and low effort–low reward), employees' sickness absence frequency was low. Even though especially high effort seems to lead to sickness absence (see steep rise in front on the

Table 3. Hierarchical multiple regression analyses of sickness absence (Study 1; $n = 338$ due to listwise deletion)

	Frequency						Duration					
	DC model			ERI model			DC model			ERI model		
	MI	RE	Rat	MI	RE	Rat S	MI	RE	Rat	MI	RE	Rat S
1. Sex	0.20[a]	0.03[b]	0.03[b]	−0.07[a]	0.01[b]	0.00[b]	−0.45[a]	−0.03[b]	−0.03[b]	−0.83[a]	−0.05[b]	−0.04[b]
Age	−0.02*	−0.14*	−0.14*	−0.03*	−0.13*	−0.10#	−0.02	−0.05	−0.05	−0.02	−0.04	−0.01
Education	−0.18*	−0.14*	−0.14*	−0.20**	−0.15**	−0.17**	−0.23	−0.06	−0.06	−0.31	−0.09#	−0.13*
Contract (full/part time)	0.31	0.07	0.07	0.10	0.02	0.05	0.27	0.02	0.02	−0.32#	−0.03	−0.04
2. Demands	0.31	0.08	0.08	0.45**	0.15**	0.14*	0.70	0.07	0.07	0.66	0.09	0.08
Resources	−0.54*	−0.12*	−0.12*	−0.56**	−0.16**	−0.15*	−2.36**	−0.20**	−0.20**	−2.27**	−0.24**	−0.25**
1. Sex	0.19[a]	0.03[b]	0.03[b]	−0.02[a]	0.01[b]	0.00[b]	−0.45[a]	−0.03[b]	−0.03[b]	−1.10[a]	−0.06[b]	−0.04[b]
Age	−0.02*	−0.14*	−0.14*	−0.03*	−0.13*	−0.10#	−0.02	−0.05	−0.05	−0.02	−0.04	−0.01
Education	−0.18*	−0.14*	−0.13*	−0.20**	−0.15**	−0.17**	−0.23	−0.06	−0.07	−0.31	−0.09*	−0.13*
Contract (full/part time)	0.30	0.08	0.08	0.11	0.03	0.05	0.25	0.03	0.02	−0.33	−0.03	−0.04
2. Demands	0.34	0.19	0.19	0.44**	0.15**	0.15*	0.75	0.12	0.00	0.65	0.09	0.07
Resources	−0.53*	−0.22	−0.22	−0.45*	−0.13*	−0.15*	−2.33**	−0.25	−0.15	−1.91**	−0.20**	−0.23**
3. Interaction (MI/RE/Rat)	−0.45	−0.16	−0.15	−0.53#	0.07	−0.01	−0.71	−0.07	0.09	−1.63*	0.10#	0.05
R^2 (Study 1)	0.066	0.064	0.064	0.117	0.113	0.104	0.063	0.062	0.062	0.110	0.106	0.111
R^2 (Study 2)	0.058	0.025	0.022	0.046	0.040	0.030	0.018	0.019	0.019	0.041	0.040	0.047
Incremental F-test (Step 2 vs. 3)	$F = 0.92$	$F = 0.35$	$F = 0.24$	$F = 3.19$#	$F = 1.57$	$F = 0.00$	$F = 0.33$	$F = 0.08$	$F = 0.09$	$F = 4.32$*	$F = 2.82$#	$F = 0.41$
Incremental R^2	0.003	0.001	0.001	0.009	0.004	0.000	0.001	0.000	0.000	0.012	0.008	0.001

#$p < 0.10$; *$p < 0.05$; **$p < 0.01$.
[a]Unstandardized regression coefficients (B); [b]standardized regression coefficients (beta).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coefficients did not differ between Study 1 and Study 2. The patterns for exhaustion turned out to be very stable across samples. The other outcome variables were stable as well, although sometimes the effect size differed, but in general the pattern was similar in both samples (i.e., the direction of the regression coefficients).

Discussion

The present study addressed a theoretical overview of interaction effects between job demands and job

as well as a similar pattern of the ratio for exhaustion and psychosomatic health complaints (see Figures 2–5). Comparing the figures of the multiplicative interaction (Figures 2 and 4) with the ratio (Figures 3 and 5) showed that patterns differed considerably across different interaction terms. Although for both interaction terms having high demands and low decision latitude was most stressful, the other conditions differed. For a multiplicative term, having high decision latitude and low demands was stressful, too. Furthermore, when demands and decision latitude were both high or both low, less strain was experienced. In the case of a ratio, almost no strain was experienced among those having high decision latitude (regardless of the amount of demands). However, some strain was experienced among those having low demands and low decision latitude. In sum, especially the low demand–high decision latitude condition differs; whereas the multiplicative term showed a moderate amount of strain, the ratio showed no strain at all.

That two essentially different interaction terms (i.e., multiplicative and ratio term) may yield significant results for the same variables (but in separate regression analyses) underlines the importance of making a *theoretical* choice for a specific interaction term. So, apart from the 'high strain' condition, one's preference for a particular interaction term would depend on the assumptions one has. If it is assumed that only the high strain condition leads to strain and the other conditions are about equal, the ratio form would seem to best fit this pattern. However, if it is assumed that not only overload is stressful, but also *under*load (see Warr, 1994), a multiplicative term would be preferable. It should be noted that the practical implications differ as well. For a ratio form, intervening only on decision latitude would be recommended. Once the employee experiences high decision latitude, the level of demands does not alter the (low) level of strain. However, in the case of a multiplicative term, both the amount of demands and decision latitude should be considered. In a high strain condition (i.e., high demands–low decision latitude), increasing decision latitude would be beneficial, whereas in a passive situation (i.e., low demands–low decision latitude) this would not be beneficial. In order to reduce strain, the amount of demands and the amount of decision latitude should be more or less equal.

Remarkably, a clear distinction between self-reported health outcomes and registered outcomes (i.e., sickness absence) appeared. Whereas significant interactions were found for all self-reported outcomes, none of the interaction terms turned out to be significant for the registered outcomes (i.e., sickness absence). This result is consistent with the literature regarding DC studies. Many DC studies have supported the DC model with regard to self-reported health, whereas the few studies of sickness absence generally did not find a significant interaction (e.g., De Jonge, Reuvers et al., 2000; Godin & Kittel, 2004; Vahtera, Pentti, & Uutela, 1996). In general, DC studies for sickness absence showed a main effect of decision latitude, but not always for demands (e.g., De Jonge, Reuvers et al., 2000; Godin & Kittel, 2004), a result similar to our study. Possibly, having more decision latitude allows employees to adapt their work situation to their health condition (for example, having more breaks), which is necessary when not feeling well to cope with work regardless the amount of demands. However, as for the full model, i.e., the interaction between demands and decision latitude, the current study seems to lend more support for self-reported, more psychological/emotional outcomes as compared to more behavioral/physical outcomes.

Cross-validating the results in a comparable sample (Study 2) showed that all results could be replicated within the allowed shrinkage on cross-validation. Moreover, the pattern of the regression coefficients did not significantly differ between the two samples. In general, this indicates that our tests of the DC model lead to stable results across samples.

Effort–reward interaction: empirical findings

Testing alternative formulations of ERI interactions with the help of regression analyses showed that, contrary to expectations, mainly the multiplicative interaction term (instead of the commonly used ratio term) yielded significant interaction effects. Whenever significant interaction effect(s) appeared

for an outcome variable, a multiplicative interaction term was (one of) the type(s) of interaction(s) used, showing a consistent pattern of the multiplicative interaction term. Further consistency was found in the results for sickness absence duration, as different kinds of interaction terms were simultaneously significant (i.e., multiplicative interaction term and relative excess term). Since more support was found for a multiplicative interaction and the effects of this type of interaction were stronger than for the relative excess term, we assume that rewards can be seen as a modifier of the relation between effort and strain (i.e., sickness absence). Drawing the multiplicative interactions into three-dimensional plots supports the notion that high rewards buffer the effect of high effort on sickness absence (which is also the meaning of the saddle-shaped pattern). As employees with both low rewards and low efforts stayed sick at home slightly longer, it appears especially that rewards are important for reducing sickness absence duration. For the relative excess term, it appeared that increasing rewards would also decrease sickness absence, but to further decrease sickness absence efforts should be reduced as well.

Sickness absence is considered a behavioral outcome, which can be interpreted in different ways. It can be seen as a result of physical health (i.e., being sick) or as a result of a motivational process (i.e., being motivated for whatever reason to stay at home for a shorter or longer period). As the ERI model is based on the principle of social exchange, it can be seen as an equity process (see Siegrist, 1996). For that reason it is possible that employees stay ill at home longer to compensate for occupational rewards (i.e., salary, status, respect) that they feel they should have received. In this way, sickness absence could be dependent on motivational reasons as well as actual illness.

Contrary to previous studies (e.g., Kuper, Singh-Manoux, Siegrist, & Marmot, 2002; Pikhart et al., 2001), the current study did not support the ERI model with regard to self-reported health. However, as Belkiç and colleagues (2000) noted, most studies did not separately test for an interaction effect, so that interaction effects (in addition to main effects) are unknown. Another reason might be that the present study used the original questionnaire of the ERI model, whereas the other studies used proxy measures for effort and reward (see Van Vegchel et al., 2005). In addition, the original ERI questionnaire asks for the amount of distressfulness that is experienced for effort and reward, reflecting how stressful the job is *perceived* to be. Wall, Jackson, Mullarkey, and Parker (1996) have argued that by including affective elements in the independent as well as the dependent variables, a spurious main effect is built into the observed relationship. This common method variance increases the main effects of effort and reward on psychological strain, thereby restricting the opportunity to demonstrate an underlying interaction between effort and reward. Since this problem does not occur by using a more objective outcome, this might explain why interaction effects were found for sickness absence, but not for self-reported health. On the other hand, it might also be the case that effort and reward are less important components for predicting psychological health, as opposed to physical health.

Cross-validation of the ERI model in the other sample showed that only the findings regarding sickness absence could be replicated in the second study. The results could not be replicated for exhaustion and psychosomatic health complaints within the allowed shrinkage on cross-validation. Nevertheless, the patterns of the regression coefficients in general did not differ between the two studies. To conclude, the ERI model seems to be less stable across samples for self-reported health.

Demand–control and effort–reward interactions

The empirical findings for the DC model and the ERI model show that the multiplicative interaction term was the only interaction term that yielded consistent results for both models. The ratio term was also an important type of interaction, but only for the DC model. This is quite remarkable, since it was hypothesized that the ratio term would have been a main interaction term for the ERI model. Thus, the empirical results suggest it is plausible to regard the interactive relationship between job demands and job resources in the prediction of job-related strain as multiplicative. This means that both demands and resources have an impact on the amount of strain (beyond their mere additive effects). More

specifically, when demands do not equal resources (i.e., especially high demands–low resources) strain will experienced. On the other hand, when demands equal resources almost no strain is experienced. So, it is possible to have high demands without experiencing strain as long as resources are also high.

Whereas all significant DC interactions were related to self-reported health, all ERI interactions

influence Time 2 employee well-being), than for a reversed or reciprocal pattern. However, although longitudinal samples are most appropriate for testing hypotheses of causality, they are no panacea for all research questions (see Taris & Kompier, 2003). The methodological and technical points of the current study could equally be tested with cross-sectional databases. In addition, although it is plausible to assume that employee well-being may influence the perception of job characteristics, it is theoretically less feasible to assume that employee well-being will lead to an interaction between job demands and job resources over time. Further, it cannot be ruled out that the relationship between job demands, job resources, and outcomes is influenced by a 'personality characteristic,' most notably negative affectivity (NA). Research, however, seems to justify the omission of this potential confounder in job stress research using self-reports (e.g., De Jonge et al., 2001; Moyle, 1995). In addition, Karasek et al. (1998) argued that the cure could be worse than the problem and could easily be overdone, leading to Type II statistical errors: true variance in strain measures could be removed with NA. Similarly, after reviewing a range of possible mechanisms by which NA could affect the stressor–strain relationship, Spector, Zapf, Chen, and Frese (2000) argued that partialling NA out is the wrong approach; instead a better quality of data is the way forward. However, all these points do not negate the fact that to make strong(er) causal inferences the current findings await further longitudinal examination.

In addition, the amount of variance explained by the interaction terms was quite modest (ranging from 0.008 to 0.018). However, in our opinion this neither negates the theoretical importance nor means that the interaction effects have little substantive significance (see also Frese & Zapf, 1988; Wall et al., 1996). The results are important because the size of the interaction effect is attenuated by measurement error when interaction terms are formed by multiplying variables to form cross-product terms as is required in regression analyses (Aiken & West, 1991). Also, Semmer, Zapf, and Greif (1996) indicate there is an upper limit of 10 per cent of the variance which can be explained by a stressor–strain relationship, due to methodological considerations as well as the multi-causal aetiology of (poor) well-being (see also Zapf, Dormann, & Frese, 1996). Therefore, we think that the results do have some theoretical value, distinguishing different statistical interaction terms within the DC model and the ERI model.

Second, the fact that our samples contain employees of a single industry (i.e., nursing homes) entails both strengths and weaknesses. An advantage is that it mostly eliminates the major socio-economic status factors that are confounded with both health status and occupational differences (see Ganster et al., 2001). A limitation of single-occupation sampling, however, is that the variation in job characteristics might be restricted, in comparison with larger multi-industry studies. Therefore, the power to detect interaction effects might be limited. Fortunately, health care occupations are likely to have some natural variation in job characteristics due to different specialties and different occupations within nursing homes (Fox et al., 1993; Ganster et al., 2001). Research into nursing professions is important because their quality of work and well-being is conditional for the future well-being of rather large segments of industrialized working populations. Nevertheless, in order to generalize the results to other occupations (especially male populations), more research in multi-occupational groups is needed.

Third, the reliabilities of Study 2 were slightly lower than the reliabilities of Study 1. Because of lower reliabilities, associations between variables might be underestimated (i.e., attenuation), and consequentially the amount of explained variance could be reduced (e.g., Dooley, 1984). As a result, this might have influenced the cross-validation such that results appeared to be somewhat less reliable across samples.

Finally, only the extrinsic components of the ERI model were explored; that is, the interactive relationship between effort and reward. However, a complete test of the ERI model requires that its intrinsic component 'overcommitment' should be included as well (Siegrist, 2002). Especially, the

relation between effort–reward imbalance and overcommitment should be explored and amplified upon in future research.

In spite of those limitations, the present study provided an enhanced theoretical overview and a thorough empirical test of different interaction terms within the DC model and the ERI model. As different interaction forms behind the formulations of the interaction terms do have different meanings for the interpretation of interaction effects, it is important to consider carefully which interaction term (and implicitly which interaction form) provides the best representation. Moreover, practical implications seem to differ as well. Whereas enhancing job resources is sufficient in the case of a ratio, in the case of a multiplicative term and relative excess term the amount of job demands might be considered as well. Based on the empirical findings, a multiplicative interaction seemed to be the most consistent representation of the relation between job demands (i.e., demands or efforts), job resources (i.e., decision latitude or rewards), and strain. It is hoped that the present study will provide an impetus to more critically examine the interactive relationship of job demands and job resources in the prediction of employee well-being. Future job stress research may benefit from the idea that there should be a theoretical preference for any interaction form, either in the DC model or in the ERI model. Nevertheless, it is still preferable to test several different forms of interaction in future studies. Consistency of results would provide evidence for a true interaction effect, showing that occupational stress is in (inter)action.

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