ASPECTS OF THE EFFORT REWARD IMBALANCE MODEL OF PSYCHOSOCIAL STRESS IN THE WORK ENVIRONMENT

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To Kerstin, my mother
ABSTRACT


Since the late 1970s, work related stress has increasingly been recognized as an important determinant for ill-health and disease. One of the most influential stress models is the Effort-Reward Imbalance model (ERI), which stipulates that an imbalance between the perceived effort spent at work and rewards received results in noxious stress. Those with a coping behaviour called Work-related Overcommitment (WOC), including an inability to withdraw from work obligations are especially vulnerable. The model has shown strong explanatory value for a large numbers of harmful health outcomes.

The general aim of this thesis was to contribute to the development of the ERI model by exploring the properties of this model in relation to its theoretical assumptions, construct, and application and to improve the knowledge of validity of the ERI-model.

The study sample that was used in three papers emanated from the WOLF study (Work, Lipids and Fibrinogen). The analyses were confined to the subset of individuals who answered the ERI questions (n=1174) with complete answers. In one paper, data from the SKA study (Sick leave, Culture and Attitudes) were used and they comprised all employees at the Swedish Social Insurance Agency responsible for management and compensation of illness in the working population (n=5700). All data are based on questionnaires.

The results indicate that ERI and WOC are risk factors for sleep disturbances and fatigue. A palpable threshold effect was seen between quartile three and four. Since these symptoms are strongly stress related, our results support the utility of the ERI and WOC scales in assessing stress in working life.
Agreement between single questions in the original and an approximate instrument for measuring ERI were low, whereas the agreement between the two ERI scales was reasonable. When approximate instruments are used, questions and scales must be presented thoroughly to facilitate comparisons and the results should be interpreted with caution. Today there are no reasons to use such instruments in the ERI model.

One statement in the ERI model is that individuals with the coping behaviour characterised as WOC are particularly vulnerable to an imbalance between perceived effort and reward; i.e., that ERI and WOC interact. No such effect was shown in relation to disturbed sleep and fatigue. There is no convincing evidence that ERI and WOC interact in synergy. Analysis demonstrated that WOC was relatively stable in perceived unchanged conditions as measured by the original, more comprehensive instrument as well as by the present, shortened instrument. Positively or negatively perceived changes in ERI correspond to changes in WOC. This result suggests that WOC, at least in part, may act as not only a coping strategy but also as an outcome from ERI. Taken together, these results concerning WOC, suggest that studies to clarify the role of the WOC dimension are needed.

The ERI model states that, when individuals stay in unfavourable conditions characterised as ERI, because there are few alternatives on the labour market or when the individual is at risk of being laid off or of facing downward mobility, they are in a “locked in position” (LIP). A strong association between LIP and ERI was shown, supporting this statement.

Keywords: Psychosocial stress, Effort-reward imbalance, Working life
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Sundsvall, May 2008
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LIST OF PUBLICATIONS

This thesis is based on the following studies, which will be referred to in the text by their Roman numerals:


III. Fahlén, G. Goine, H. Edlund, C. Arrelöv, B. Knutsson, A, Peter, R. Effort-reward imbalance, “locked in” at work, and long term sick leave. (In press *International Archives of Occupational and Environmental Health*).

IV. Fahlén, G. Knutsson, A. Peter, R. Alfredsson, L. Westerholm, P. Evaluating stability and reactivity in work-related overcommitment under the ERI model: does the shortened questionnaire lead to changes in model properties?” (In manuscript)

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### ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>DC</td>
<td>Demand control (model)</td>
</tr>
<tr>
<td>CVD</td>
<td>Cardiovascular disease</td>
</tr>
<tr>
<td>CHD</td>
<td>Coronary heart disease</td>
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<tr>
<td>ERI</td>
<td>Effort-reward imbalance (model)</td>
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<tr>
<td>KSQ</td>
<td>Karolinska sleep questionnaire</td>
</tr>
<tr>
<td>LIP</td>
<td>Locked in position</td>
</tr>
<tr>
<td>NA</td>
<td>Negative affectivity</td>
</tr>
<tr>
<td>OHS</td>
<td>Occupational health service</td>
</tr>
<tr>
<td>SKA</td>
<td>Cross-sectional study on sick leave, culture and attitudes</td>
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<tr>
<td>WOC</td>
<td>Work related Overcommitment</td>
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<tr>
<td>WOLF</td>
<td>Cohort study (WOrk Lipids and Fibrinogen)</td>
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INTRODUCTION

Since the late seventies, work-related stress has, to an increasing extent, been recognised as an important determinant for ill-health and disease. To gain insight into the relationship between work characteristics and employee health, occupational health researchers have tried to reduce the complex reality into stress models, which, out of necessity, highlight only some core elements.

One of the most influential models is the Effort-Reward Imbalance model (ERI) introduced by Siegrist (1996a). The model emphasizes the potential imbalance between efforts spent and rewards received at work. The model has shown strong explanatory value for a large number of harmful health outcomes and has been judged to be an important tool for understanding stress in working life (Kasl 1996; Siegrist 2005; van Vegchel, de Jonge et al. 2005).

When my doctoral studies started in 1998, there was an on-going discussion about the possible contribution to public health from psychosocial stress models, such as the well-established Demand Control (DC) Model by Karasek (1979) and the more recently presented Effort-reward imbalance model (ERI) by Siegrist (1996a). The principal interest, so far, and the major part of the research concerned the relationship between stress and cardiovascular diseases, whereas the relationship between the ERI model and other stress-related health outcomes was less studied. Methodical issues were also addressed. Kasl, who examined both the models pointed emphasized that it not was clear how intra- and interpersonal variations affected the stability of the instruments. Nor were the mechanisms behind made clear. It was not fully analysed to what extent they measure what they intend to. Moreover he claimed that there was a reason to assume that the uncertainty probably caused a dilution effect and that a more certain instrument would estimate higher increases of risks at high psychosocial stress in work. He stated that, at that time, the relatively recent ERI model offered exciting and innovative formulations, and he felt: “… that it would be premature second-guessing if one questioned, at this stage, the general direction in which this formulation is heading” (Kasl 1996, p. 51).
Hence it was of interest to study the conceptual ideas to gain a deeper understanding of the ERI model and the model construct and also to test the ERI model in relation to a health outcome strongly associated with stress.

The general aim of this thesis was to contribute to the development of the ERI model by exploring the properties of the model in relation to its theoretical assumptions, construct and application and to improve the knowledge of validity in the ERI model.
BACKGROUND

Working life of today

The working conditions in Europe have undergone considerable changes over the last decades. Rapid technological development, increased global competition, changing consumer demands, growth of the service sector, just-in-time management, et cetera have resulted in increasing variations in work organisation, working hours, wages and even workforce size at different stages of the production. Part-time and fixed-time jobs have increased, as have on-call contracts, contracts through temporary employment agencies, and freelance contracts (European Commission 2006). The European Employment Taskforce has warned of a two-tier labour market, divided between permanently employed “insiders” and the unemployed, those detached from the labour market or precariously and informally employed as “outsiders”. The latter group runs the risk of significantly reduced basic employment or social protection rights and faces uncertainty about future employment prospects. Such situations affect crucial choices in one’s private life, such as planning a family (Taskforce 2003). Having a job is a principal prerequisite for continuous income and social status (Peter and Siegrist 1999). Economic insecurity has been shown to cause adverse health effects by “economic stress” (Starrin, Forsberg et al. 1999). That implies that the importance of work for well-being and health goes beyond traditional occupational diseases. Peter and Siegrist (1999) have stated that there is a challenge “in conceptualising aspects of the current and near future work conditions that adversely affect health and to delineate ways to reducing the burden of ill health” (Peter and Siegrist 1999, p.441).

Today, fewer jobs are defined by physical demands than by mental and emotional demands. The number of jobs in the industry sector has been reduced while the service sector expands, and more jobs are concerned with information processing. The European Commission has stated that the changes in how work is organised have a profound effect on problems associated with health at work and well-being. The Commission declared that the European Community should follow the changes and new demands in working life to promote comfort and well-being at work, by physical, psychological and social means, which cannot be measured only by the absence of accidents or occupational
diseases (European Commission 2000). The World Health Organization (WHO) has defined that work-related diseases include all diseases for which aetiology work contributes, not only work accidents and injuries. There has also been a strong trend in Europe to expand the concept of occupational health to overall protection and promotion of health at work (WHO 2002).

According to Levi (2002), there is no doubt that working life and working conditions are powerful determinants of health, positively or negatively. One of the health hazards are noxious, work-related stress.

**Stress**

The word stress emanates from Seyle, who intended to describe the stereotypy, the generality in the organism’s tendency to react to widely differing chemical and other type of stimuli. According to Levi, Seyle wanted to use a heavily-loaded bridge as a metaphor for the phenomenon. The choice of the word stress emanated from a misunderstanding of the physical terminology. “Strain” seems to be a more appropriate word (Seyle 1971; Levi 1996).

In the early history of mankind the stress reaction helped our ancestors to survive dangers. The cerebral cortex signalled to their hypothalamus to prepare for fight or flight by passing on the signal to every part of their bodies through the nervous, endocrine and immune systems to increase such preparedness. Now, existence is dramatically different, but our genetic programming in combination with long-lasting occupational and other environmental exposures have become a threat to our health and well-being (European Commission 2000).

Stress is a subjective response resulting from the interaction of particular objective social conditions and with particular personal characteristics (House 1974). A stressful experience is a not only the result of a stimulus but also a result of the cognitive and emotional reactions to a stimulus (Lazarus and Folkman 1984). Several different stressors can cause stress. It can be a misfit between what we need and what we are capable of or between what our environment offers and what it demands of us. Role conflicts can also cause stress (Levi 1996). Stress in the biological sense cannot be eliminated, but what we need is
to avoid unnecessary and noxious stress. Levi (1992) claims that our sense of control is critical. Our influence over various aspects of our own lives, is a strong determinant of whether stress becomes a positive challenge or a threat, a “Spice of life - or kiss of death?” (European Commission 2000, title page) Coping strategies are decisive for how individuals estimate, interpret and respond to situations that are challenging, threatening, harmful or associated with loss. Coping can be defined as thoughts and behaviours used to handle situations that are appraised as stressful and demanding (Lazarus and Folkman 1984).

The European Commission (2000) has defined work-related stress as “the emotional, cognitive, behavioural and physiological reactions to adverse and noxious aspects of work, work environments and work organisations. It is a state characterised by high levels of arousal and distress and often by feelings of not coping” (European Commission 2000, p. 3). According to Kasl (1992) occupational stressors can be considered to be a long-term risk for health and well-being if four conditions are met 1) the stressful conditions are chronic; 2) adaptation is difficult because permanent concentration is required; 3) there are serious consequences associated with failure to meet demands; and 4) the problems affect other spheres of living, resulting in cumulative effects. Levi (1992) has listed diseases that are directly associated with stressful work-situations; cardiovascular diseases, cancer, musculoskeletal diseases, gastrointestinal diseases, anxiety disorders, depressive disorders, accidents and suicides. Regarding cardiovascular diseases, it is estimated that 16% of the cardiovascular diseases in male and 22% in female employees are caused by work-related stress.

The Effort-reward imbalance model

Background to the ERI model

To gain more knowledge about the relationship between work characteristics and health, researchers have developed stress models to reduce the complex reality into approachable data that can be used in epidemiologic analyses. The different models highlight different, but often similar core elements and use different concepts or instrument for analysis. The best-known model is probably the Demand Control model
by Karasek (1979), but over the last ten years the ERI model (Siegrist 1996a) has been increasingly known and used.

In 1986, Siegrist and his group introduced some of the fundamental features in a sociological framework, which later were developed to a complete stress-theoretical model applicable to working life, ERI (Siegrist, Siegrist et al. 1986; Siegrist 1996a; Siegrist 1996b). At that point, the main interest was in cardiovascular outcomes, but, more recently the interest has expanded to include various health outcomes (Siegrist 2005; van Vegchel, de Jonge et al. 2005). Siegrist claimed that medical sociology and social epidemiology lacked multidimensional analyses of the phenomena of social inequality and argued that information on the conditions of status control, chronic and/or sub-acute social stressors, as well as information on the threshold of individual adaptive coping, is needed to predict cardiovascular breakdowns (Siegrist 1996a).

In one of the core articles concerning ERI, Siegrist (1996a) discusses two earlier models he considered to be the most important conceptual approaches to explore how critical components of working life affect human health. The first model, the person-environment fit model, puts the emphasis on the stressful experiences of incongruence between individual abilities and job demands and also between individual goals or aspirations and the possibilities offered by the work environment. The appraisal of this incongruence triggers coping mechanisms and strain reactions (French, Caplan et al. 1982). Siegrist claims that this model fails to answer stress-theoretical questions, e.g., about the relevance of the included job dimensions, the impact of the work situation on individuals and how individuals cope in a stressful situation (Siegrist 1996a).

The second model, the DC model, by Karasek (1979), emphasises the combination of high demands and low decision latitude in a job, resulting in job strain as the stressful and harmful condition. In this model, the control dimension is restricted to objective task characteristics, decision authority and skill discretion (Karasek 1979). Karasek and Theorell assume that stress-related illnesses "are not determined solely, or even primarily, by personal factors" (Karasek and Theorell 1990, p. 6). Siegrist et al. (2004) claim that variations in psychological arousal due to individual modes of coping therefore
remain unexplained and that the DC model thereby represents a “black-box” approach towards studying work stress, restricting the analysis to the structural level and not integrating structural and personal components (cf. Lazarus and Folkman 1984; Levi 1996). The ERI model was presented to demonstrate how those unanswered stress-theoretical questions could be approached in a somewhat different conceptual framework.

In his book “Sociale Kriesen und Gesundheit”, Siegrist (1996b) thoroughly develops the background of the model. The situation of today is full of market and structural crises, as well as crises in the political and the societal systems. When these types of crises arise, our traditional patterns of solving problems fail to work. The crisis contains two components; on one hand inter-subjective, far-reaching changes of conditions for which an individual is not prepared and, on the other hand, the subjective experience and appraisal process that arises through the threatening and challenging situations that people are facing. The primary biological pathway is through affective and cognitive processes which activate the autonomous nervous system. In general there are three factors that influence health that can be distinguished but that also interact with each other; genetic factors, individual’s acting and appraisal, and, finally, influences from the physical and social environment. The three-factor approach makes the definition of the problem area broad, but, according to Siegrist (1996b), it is necessary to include those perspectives to gain new insights about social crisis to develop preventive achievements and also to utilize knowledge from sociology, psychology and biomedicine in an interdisciplinary venture.

The interest of knowledge, therefore, addresses the interaction between the organism, the individual and the surrounding world in one respect, namely, the exchange between the individual and the social environment. It is important, whether the individual gains a positive or negative self-experience, a central aspect of self-regulation. To understand this starting point, Siegrist emphasises the social-anthropologic background. During evolution two motives to self-regulation have dominated, and by this means the exchange between the individual and the environment, namely self-preservation and reproduction. The human being has the requirements to build
relationships, and through appraisal and thoughts the self-experience become a “theme” of social exchange. The individual looks upon him- or herself through a mirror of deeds and reactions from significant others who interact with him/her, and positive feed-back is of importance for the individual’s self-esteem. A core hypothesis is that there is a systematic association between the quality and the intensity of emotions, which, through self-regulation, result in social exchange. This exchange influences neurologic, neuro-endocrine, and endocrine processes along with immune processes, which essentially determine health (Siegrist 1996b).

The importance of the social exchange, e.g., positive or negative feed-back, is supported by Marmot (2004), who comprehensively examines the research field in his book - *The Status Syndrome: how your social standing directly affects your health*. He concludes that the degree of control that individuals have over their lives and the possibilities of social cohesion and participation are decisive for health. He claims that the importance of the relative position in society is obvious and lists several gradients, e.g., salary, education, job status, all powerful factors that are associated with health behaviour, ill-health and mortality (Marmot 2004).

**The core concept, the components and the development of the ERI-model**

In the ERI-model, reward is introduced as an essential component of working life. The model stresses the work role as a crucial link between self-regulatory functions (self-esteem and self efficacy) and the social opportunity structure (cp. the previous paragraph). It can provide options to contribute and perform, to receive reward or esteem, and to belong to a significant group. The potentially beneficial effects of the work role are based on the prerequisite that a reciprocal exchange underlies all transactions in social life. At work, reciprocity can be expressed as a balance between perceived effort invested (extrinsic effort) and rewards received, by means of monetary gain, esteem, and career opportunities, including job security. A deviation from this reciprocity threatens a person’s self-regulatory functions, i.e. the sense of mastery, efficacy, and esteem. It evokes the strong recurrent negative emotions of fear, anger and irritation. ERI thereby leads to a condition of
emotional distress and propensity to autonomic arousal and associated strain reactions (Siegrist 1996a). ERI has also been described as a result of incomplete contracts, where assumptions of mutual commitment are not met (Siegrist 2005). Later, the importance of the quality in other core social roles outside work in adult life, such as partnership, parent-child and general trusting relationships, or relevant civic roles has also been emphasised (Knesebeck and Siegrist 2003; Chandola, Marmot et al. 2007).

According to the expectancy value theory, it is likely that individuals in unfavourable situations, e.g., ERI, will act to minimize or dismiss the high-cost/low-gain conditions by changing jobs or by reducing their efforts (Schönpflug and Batmann 1989). In contrast, Siegrist (1996a) point out three situations when this assumption is not valid. The first is a situation with few alternatives on the labour market and in risk of being laid off or of facing downward mobility. This situation has been designated by Aronsson (2000) as being “locked in”; in this thesis it is named “locked in position” (LIP) and is described in more detail later (Aronsson, Dallner et al. 2000). The second situation is when people perceive opportunities to compete for promotion prospects by extra work and additional responsibilities. Finally, the third situation is when a coping behaviour called Work Related Overcommitment (WOC) is present. Overcommitment is characterized as a set of attitudes, behaviours and emotions reflecting excessive strive combined with a strong desire for approval and esteem (Siegrist 1996a). In situations when ERI is present, individuals characterized by overcommitment will exaggerate their efforts because of their desire for approval and esteem (Peter and Siegrist 1999).

The effort and reward dimensions and the ERI quotient

The effort dimension includes six items and concerns; physical work load time pressure, interruptions, responsibility, working overtime and increasing demands (See appendix 1). Later, physical work load has been considered to be psychometrically appropriate only in samples that are predominantly not characterised by white-collar jobs and it was therefore excluded in the studies included in this thesis (Siegrist, Starke et al. 2004).
Reward is operationalized by means of 11 items, reflecting three underlying factors: money, esteem, and security/career opportunities, a structure confirmed in several studies (see appendix 1) (Siegrist, Starke et al. 2004). The last factor was originally designated status control, but to avoid confusion with the control concept in the DC model by Karasek, the labelling has been altered (Karasek, Siegrist et al. 1998). It should be noted that, in the DC model, the range of control over one’s environmental situation at work is the core dimension, while, in the ERI model, control (security/career opportunities) concerns instead threats to or violations of legitimate rewards based on social reciprocity (Karasek, Siegrist et al. 1998).

In one of his core articles, Siegrist (1996a) particularly expounded the security/career dimension. Loss of crucial social roles can represent a threat to a person’s self-regulatory functions such as his/her sense of mastery, efficacy, and esteem, thereby likely evoking strong negative emotions of fear, anger, or irritation. Occupational positions provide such crucial roles. Besides of the most obvious example, the loss of one’s job, different low reward situations such as job insecurity, forced occupational changes, downward mobility, lack of promotion prospects or under-qualified jobs as compared to the individual’s education, are examples of particularly stressful conditions when combined with high effort (Siegrist 1996a).

Later, Siegrist has provided a shortened, tested questionnaire, containing ten items, three concerning effort and the other seven concerning reward (see appendix 1).

The joint measures of unfavourable distribution of extrinsic effort and reward are assessed by a quotient between effort and reward, where a high value constitutes a harmful situation, ERI.

**Work Related Overcommitment (WOC)**

Work-related overcommitment has been characterised as an individual motivational pattern of excessive work-related performance and achievement. The WOC dimension and measure has been developed in many steps. In 1986, a personality dimension, named “Need for control”, was presented by Siegrist’s group from a
critical analysis of the more global “type A” behaviour concept, primarily in relation to cardiovascular diseases (Matschinger, Siegrist et al. 1986). The type A behaviour pattern is described as a set of behavioural dispositions, which include ambitiousness, aggressiveness, competitiveness, and impatience. Also, specific behaviours such as muscle tenseness, alertness, rapid and emphatic voice style and pace of most activities are included, as well as emotional responses such as irritability and increased potential for hostility and anger (Rosenmann 1983). An important motivational basis of type A behaviour is a strong need for control. Besides a genetic component, primary socialization during childhood and early adolescence plays an important role for developing the “need for control”, by model learning or by acting as a compensation for low self-esteem or marginal socio-emotional status (Matschinger, Siegrist et al. 1986).

Fear of losing control stimulates overcommitment, either by (1) underestimation of demands in combination with overestimation of coping potential or by (2) overestimation of demands and underestimation of resources. These cases represent two different stages in a “coping career” (Matschinger, Siegrist et al. 1986). The first stage is likely to occur in early adulthood when good health, professional training and achievement motivation lead to increased responsibility and job involvement. Individuals with a strong sense of control do not, however, perceive distressing experiences in an adequate way. Therefore, coping patterns established in early adulthood persist even if earlier coping behaviours are no longer successful. Those who continue to underestimate demands and overestimate coping potential while maintaining their vigorous efforts over prolonged periods of control-limited conditions, such as poor job security, no positive feedback from supervisors and uncertainty about a payoff of invested efforts, are at risk for deleterious health consequences. The second step in the coping career occurs when the distressing experience increases, when signs of fatigue become more apparent and feelings of immersion are admitted. Realistic awareness of coping failure, however, is often not present until the onset of a disease. In this context, successful efforts are thought to be harmless, while efforts followed by poor payoffs or by a loss of control have a critical impact. Work-related
overcommitment represents a coping pattern that reinforces the impact by high-effort, low-reward conditions (Matschinger, Siegrist et al. 1986).

The “Need for control” pattern was measured by 44 dichotomous items that represented six dimensions: 1 - need for approval, coping with success and failure; 2 – competitiveness, independence during challenge and latent hostility; 3 – work commitment, hard driving; 4 – perfectionism, need for making plans; 5 – impatience and disproportionate irritability; and 6 – inability to withdraw from work obligations. By factor analysis and from the theoretical assumptions discussed above, two factors crystallised. The first, “vigour”, loaded on subscales 3 and 4 and was judged as a state of active efforts with a high probability of positive feedback. The second factor loaded on the other subscales and was named “immersion”, which instead reflected a state of exhausted coping pattern “reflecting frustrated, but continued efforts and associated negative feelings”. The immersion dimension was defined by 29 items that were included in the ERI model as “intrinsic effort”, sometimes designated “need for control”, the same as the 44-item concept (Matschinger, Siegrist et al. 1986; Siegrist 1996a). Later intrinsic effort was renamed Work Related Overcommitment and was presented as “a state characterised as a set of attitudes, behaviours and emotions reflecting excessive strive combined with a strong desire for approval and esteem” (Peter and Siegrist 1999, p.443) (Items in appendix 2). Besides a genetic component and primary socialization, a competitive work environment has later also been considered to contribute to development of WOC (Siegrist and Rödel 2006).

In 2004, a European comparison of the measurements of ERI was published, discussing consistency, discriminant validity and factorial structure of the three dimensions of the model. In spite of the fact that the 29-item version had shown a strong predictive value, the factorial structure of the four subscales had not been consistent in several studies. A shortened six-item version was developed based on a varimax-rotated exploratory main component analysis of data from four study samples (see appendix 3). The scale was found to result in consistently high loadings on one latent factor. Five of the items concerned the dimension “inability to withdraw from work obligations”. By factor analysis and from the theoretical assumptions discussed above, two factors crystallised. The first, “vigour”, loaded on subscales 3 and 4 and was judged as a state of active efforts with a high probability of positive feedback. The second factor loaded on the other subscales and was named “immersion”, which instead reflected a state of exhausted coping pattern “reflecting frustrated, but continued efforts and associated negative feelings”. The immersion dimension was defined by 29 items that were included in the ERI model as “intrinsic effort”, sometimes designated “need for control”, the same as the 44-item concept (Matschinger, Siegrist et al. 1986; Siegrist 1996a). Later intrinsic effort was renamed Work Related Overcommitment and was presented as “a state characterised as a set of attitudes, behaviours and emotions reflecting excessive strive combined with a strong desire for approval and esteem” (Peter and Siegrist 1999, p.443) (Items in appendix 2). Besides a genetic component and primary socialization, a competitive work environment has later also been considered to contribute to development of WOC (Siegrist and Rödel 2006).
obligations”, and one concerned “impatience and disproportionate irritability” (Siegrist, Starke et al. 2004). At present, this version is also recommended on the ERI homepage in Dusseldorf (Institut für Medizinische Soziologie).

It has been discussed whether researchers are dealing with a stable personality trait or enduring (repeated) reactions to environmental stimuli (Kasl 1996). According to Peter and Siegrist (1999), persons characterised by WOC in a situation where ERI is present will exaggerate their efforts because of their desire for esteem and approval. The characteristic of the primordial concept, “need for control” has, in an unpublished report been shown to be rather stable over time and thus does “…not merely reflect transient subjective states related to the situational conditions…” (Siegrist, Peter et al. 1990, p.1128). WOC has therefore later been redefined as being an independent concept (Siegrist, Starke et al. 2004) influencing the perception of both efforts and rewards (Peter, Alfredsson et al. 1999).

**The model of Effort-reward imbalance**

The model of ERI has undergone changes over time, principally concerning the role of overcommitment. In the first formulation, overcommitment (at that time called immersion) was presented as one of the sources of high effort at work. Individuals with this coping style underestimate the challenging situation and overestimate their own capacity, thereby tending to expend high costs in terms of job involvement even in low-gain situations, to gain “control”. The critical exposure was a mismatch between the combination of extrinsic and intrinsic effort on the one hand and reward on the other (Fig. 1) (Siegrist 1996a).
In articles concerning the ERI model, very few analyses agree with the model presented above; i.e., the scores of the extrinsic and intrinsic effort are combined before being weighted towards the reward scale (van Vegchel, de Jonge et al. 2005). Instead, the ERI quotient often has represented one scale and WOC the other, in concordance with the current model presented in figure 2. As mentioned earlier, WOC now is considered to be a psychosocial a risk factor in its own (Siegrist, Starke et al. 2004), influencing the perception of both efforts and rewards (Peter and Siegrist 1999).
The present model results in three hypotheses:
1. An imbalance characterised by high effort and low reward constitutes an elevated risk for stress-related diseases, above the risk associated with each component.
2. Individuals scoring high on overcommitment are at an elevated risk for stress-related diseases.
3. The highest risk of stress-related diseases is expected in individuals who are characterised by the co-manifestation of those conditions (Siegrist, Starke et al. 2004). This hypothesis has also been designated the interaction hypothesis (van Vegchel, de Jonge et al. 2005).

Measurement of ERI

In one of the first articles describing ERI a combination of thee sources of information was advocated to secure the validity of the measures: 1) contextual information derived from independent sources such as administrative data and objective measurements, 2) descriptive information obtained from workers through structured interviews and questionnaires, and 3) evaluative information reflecting subjective appraisal (interviews and questionnaires). It was stated that the theoretical argument required a combination of evaluative and contextual information to assess the extrinsic and extrinsic components, and this also fulfilled the methodological principle of triangulation (Siegrist 1996a).

After the so-called ERI Questionnaire was introduced (Siegrist and Peter 1997), which contained the effort, reward and WOC scales; the data collection predominantly has been restricted to self-reported data (van Vegchel, de Jonge et al. 2005). Three motives are stressed: 1) it combines descriptive and evaluative information on perceived demands, 2) it requires information on personal coping characteristics, and 3) information on distant working conditions cannot be collected in other ways (e.g. job security or adequacy of salary). The combination of results from these scales according to the suggested algorithm is judged to provide an opportunity to measure the theoretical construct (Siegrist, Starke et al. 2004).
Analysis
The analysis of ERI has also undergone changes over time. All items in the ERI-questionnaire for extrinsic effort and reward consist of two parts. The first concerns exposure for the negative view of effort or reward and has two alternatives, yes or no. The second part concerns the degree of distress this situation is causing.

The labels were: the respondent 1) does not consider (herself/himself) distressed, 2) somewhat distressed, 3) distressed, and 4) very distressed. In the first guiding principal for analysis, to be negatively exposed for the respective item, the respondent not only had to be exposed in the first respect but also, in the second part, had to have responded “distressed” or “very distressed”, resulting in a dichotomized answer to the item. The motive for this classification of the answers is that data from the questionnaire statistically are of an ordinal level. At present, the ERI website in Düsseldorff recommends calculating a sum score from the questionnaire with a rating as follows: 1) not exposed, 2) exposed, but not distressed, 3) exposed, somewhat distressed, 4) exposed, distressed, and 5) exposed, very distressed (Institut für Medizinische Soziologie). For both versions, a sum score of effort respectively reward is calculated.

To examine the joint effect of an unfavourable distribution of extrinsic effort and reward, a ratio is computed between the two scales, using the formula e/(r X c), where “e” indicates (high) extrinsic effort, “r” indicates (low) reward, and “c” is a correction factor for the difference in the number of items in the nominator and denominator (Siegrist 1996a). In the first guidelines, the respondent was considered to be exposed for an unfavourable ERI situation if the value of the ERI-quotient was greater than 1.0. Later, a continuous measure has been widely spread and it is applied in most studies. A continuous measure provides more information and, according to several studies, generates more robust statistical effects (Siegrist, Starke et al. 2004).

Health effects from ERI and WOC
In several prospective and cross-sectional epidemiologic studies, the ERI model has been shown to predict various health related outcomes. Most of the studies about harmful consequences from ERI have
concerned cardiovascular outcome but also behavioural outcomes, psychological well-being and psychosomatic health outcomes have been studied (for overview see Siegrist, 2005, Tsutsumi, 2004, or van Vegchel, 2005). The model has e.g. shown associations between ERI, overcommitment and sleep disturbances and/or fatigue (Kudielka, Von Känel et al. 2004; Ota, Masue et al. 2005; Fahlén, Knutsson et al. 2006).

In a comprehensive review, van Vegchel et al. (2005) summarized results from 45 studies, cross-sectional as well as longitudinal presented from 1986 until 2003. In many studies, approximate instruments were used, as were alternative ways of calculating ERI. The majority of studies were cross-sectional, except when cardiovascular diseases were measured as outcomes. One inclusion criterion was that at least two of the dimensions were included. The most common analysis method was logistic regression. The review examined following outcomes:

1) Physical outcomes as cardiovascular diseases, cardiovascular symptoms and risk factors, and cortisol level.

All eight studies on the incidence of CVD were longitudinal and indicated that high ERI was positively related to the occurrence of cardiovascular events with odds ratios between 1.22 and 8.98. In four out of five studies highly overcommitted employees had odds ratios for CVD between 1.18 and 4.53. Only one study examined the interaction hypothesis but did not support this hypothesis. In 13 out of 17 studies ERI was associated with CVD symptoms such as hypertension and high cholesterol, with odds ratios between 1.23 and 6.71; five out of 11 studies supported the overcommitment hypothesis, with odds ranging from 1.37 to 1.86. No study examined the interaction hypothesis. No association to the components of the ERI model was demonstrated for cortisol levels.

2) Behavioural outcomes such as sickness absence, smoking and alcohol consumption.

In one study, low reward was associated with sickness absence. In another study, smoking was associated with ERI (OR=4.34) but not with overcommitment. In a third study, ERI was shown to be associated with alcohol consumption.

3) Psycho-somatic health symptoms such as dyspepsia, musculoskeletal disorders and impaired well-being.

In 13 out of 15 studies, an elevated risk of 1.44-18.55 was seen for employees working in ERI situations. Six out of seven studies supported
the overcommitment hypothesis with odds ratios between 1.92 and 5.92. No study examined the interaction hypothesis.

4) Job-related well-being such as burnout, job satisfaction and job motivation.

Five out of six studies found associations between ERI and job-related well-being, with odds ratios ranging from 5.49 and 37.37. Two studies found associations between overcommitment and job satisfaction or work motivation. Two out of three verified the interaction hypothesis, but not in relation to all studied outcomes (van Vegchel, de Jonge et al. 2005).

To summarize, high ERI has been shown to result in an increased risk for stress-related diseases in the majority of studies, while the results for the overcommitment hypothesis were inconsistent. The “interaction hypothesis” was scarcely tested, and only two out of ten studies verified the hypothesis, at least in relation to some of the health outcomes under study. (For detailed information on the review, see van Vegchel, de Jonge et al. 2005; Bakker, Killmer et al. 2000; de Jonge, Bosma et al. 2000).

**Being “locked in” in occupation or work place**

As described earlier, according to the expectancy value theory (Schönpflug and Batmann 1989), it is likely that an individual in an annoying situation (such as ERI) would act to minimize or dismiss the high-cost/low-gain conditions by e.g. changing jobs. Changes on the labour market over the last decades, however, have reduced the odds of finding a permanent job. As a consequence, many employees stay in work situations that are undesired as related to occupation or place of work or both. Aronsson et al. (2000) have described this position as being in a “locked in” position, (LIP). Such a position has been shown to increase risks for head-ache, fatigue and low-spiritedness (Aronsson and Göransson 1999). If the occupation, as well as the place of work, is perceived to be undesired, risks for stomach troubles, uneasiness, back and neck pain, fatigue and listlessness are still higher (Aronsson, Dallner et al. 2000) Being in a LIP can represent a direct path-way to illness, for instance, if employees stay in unfit work conditions such as too physically demanding work; stress caused by the LIP can represent an indirect pathway. Contrary to the DC-model by Karasek (1979), LIP stresses control over the work situation while the DC model emphasises
control within the work situation. A situation characterized as being locked in corresponds to the situation described by Siegrist (1996a), who suggests that individuals have to stay in non-desirable situations because there are few alternatives on the labour market or because of the risk of being laid off or of facing downward mobility.

**Sleep disturbances and fatigue**

Sleep disturbances and fatigue symptoms are common in many stress-related illnesses, e.g. posttraumatic sleep disorder (Harvey, Jones et al. 2003) and burnout (Melamed, Ugarten et al. 1999; Beurskens, Bultmann et al. 2000; Grossi, Perski et al. 2003). Stress is closely related to impaired sleep (For an overview, see Åkerstedt 2006). Stress in the environment results in psychological and physiological activation (Seyle 1971). When this activation exceeds the deactivation which is a main characteristic of sleep, disturbed sleep ensues (Åkerstedt 2006). Fatigue is often a result of long-term stress or disease. One important predictor of fatigue is sleep disturbances (Åkerstedt, Knutsson et al. 2004). Fatigue refers to “a subjective symptom of malaise and aversion to activity or to objectively impaired performance” (Sharpe and Wilks 2002).

Sleep disturbances and daytime fatigue are common health problems in middle-aged and elderly populations, though they vary greatly between occupational groups (Kalimo, Tenkanen et al. 2000). When frequency was used as quantifiers, prevalence of insomnia between 6 and 34% have been reported (Ohayon 2002). Fatigue is also prevalent in the working population. Two studies on fatigue in working populations reported a prevalence of 22 and 33%, respectively (Bultmann, Kant et al. 2002; Åkerstedt, Knutsson et al. 2002). It is also a common reason to seek medical aid (David, Pelosi et al. 1990).

Shift work and non-standard working hours are important risk factors for sleep disturbances, but other adverse working conditions, such as high workload, low decision latitude, and ERI, have also shown associations with impaired sleep (Fahlén, Peter et al. 2004; Kudielka, Von Känel et al. 2004; Ota, Masue et al. 2005; Åkerstedt 2006). Sleep disturbances are shown to cause a wide range of health problems, such as depression and burnout (Gillin 1998; Ekstedt 2005). Insomnia has also been shown to increase risks for incident coronary heart diseases. In a
review of ten case-control studies by Schwartz et al. (1999), higher quality case-control studies reported risk ratios of 1.47 and 3.90 for trouble falling asleep and coronary events after adjusting for age and various risk factors. In prospective studies, sleep disturbances have also been shown to predict type II diabetes (Nilsson, Rööst et al. 2004; Meisinger, Heier et al. 2005) and obesity (Gangwish, Malaspina et al. 2005).

In summary, sleep disturbances and fatigue are strongly stress-related, common in the population and associated with serious health risks. Therefore, it is of interest to test stress theoretical models with respect to sleep disturbances and fatigue.

Sick leave

Sickness absence from work is influenced by several different conditions, and different theories have been used in attempts to explain the causal associations. Except for diseases, also the capacity for work in relation to work demands, the work environment, and the welfare systems for economic compensation in sick leave must be considered (Goine, Edlund et al. In manuscript). The Swedish Council on Technology in Health Care (SBU) has recently surveyed the current knowledge in the field of sick leave research and found methodological shortcomings, largely due to the lack of randomized studies (Alexanderson and Norlund 2004; Allebeck and Mastekaasa 2004a; Allebeck and Mastekaasa 2004b). The total cost for sick leave in Sweden corresponds to the total cost of Sweden’s health care if indirect costs as production shortfalls is included (Goine 2006). It is beyond the aims of this thesis to investigate the causes of sick leave, in aspects other than those related to the ERI model.
AIMS OF THE PRESENT STUDY

The general aim of this thesis was to contribute to the development of the ERI model by exploring the properties of the model in relation to its theoretical assumptions, construct and application and to improve the knowledge of validity of the ERI model.

The specific aims were to:

* To examine the agreement between the original instrument for estimation of effort-reward imbalance and an approximate instrument. (Paper I)

* To analyse if there, in accordance to the model, is an interaction between effort-reward imbalance and work-related overcommitment (Paper II)

* To analyse if there, in accordance to the model, is an association between situations characterized as being in a LIP in an occupation and/or at work place and effort-reward imbalance and to explore whether or not ERI acts as a mediator between LIP and sick leave. (Paper III)

* To explore the stability in unchanged working conditions and reactivity in perceived changed conditions in the original and present WOC instruments. (Paper IV)

* To analyse if there are associations between the dimensions in the ERI model and disturbed sleep and fatigue, if there are dose-response associations and if threshold effects can be detected. (Paper II)

MATERIAL AND METHODS

Table 1 on the next two pages presents an overview on the studies included in the thesis.
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<td>Title</td>
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<td>Effort-reward imbalance, sleep disturbances and fatigue</td>
<td>Effort-reward imbalance, “locked in” at work, and long-term sick leave.</td>
<td>Work related overcommitment in the ERI model – stability in unchanged, and responsiveness in perceived change in working conditions – does the shortened questionnaire lead to changed model properties?</td>
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<td>Co-authors</td>
<td>Richard Peter, Anders Knutsson</td>
<td>Anders Knutsson, Richard Peter, Torbjörn Akerstedt, Maria Nordin, Lars Alfredsson, Peter Westerholm</td>
<td>Hans Goine, Curt Edlund, Britt Arrelöv, Anders Knutsson, Richard Peter</td>
<td>Anders Knutsson, Richard Peter, Lars Alfredsson, Peter Westerholm</td>
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<td>To study the relationship between situations characterized as being in a “locked-in” position in occupation and/or workplace and whether ERI acts as a mediator between LIP and sick leave.</td>
<td>To investigate the stability of the personality dimension in the ERI model, WOC, measured by the original and the present version, in unchanged working conditions, and its responsiveness in perceived changed working conditions</td>
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<td>Employees served by occupational health units. A subgroup who answered the original ERI questionnaire.</td>
<td>Employees working with ill-health at the Swedish Social Insurance Agency</td>
<td>Employees served by occupational health units. A subgroup that took part in both studies and answered the original ERI questionnaire.</td>
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<td>Study size (with complete data)</td>
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<td>789 men 214 women</td>
<td>534 men 2951 women</td>
<td>455 men 114 women</td>
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<td>Results</td>
<td>The agreement between many of the single original ERI and approximate questions was low. Correlation between the questionnaires was reasonable.</td>
<td>High ERI and high WOC were associated with increased prevalence of sleep disturbances and fatigue. A clear dose-response relationship was seen. No interaction between ERI and WOC was demonstrated</td>
<td>High ERI was associated with being in a LIP as regards workplace or occupation. ERI act mediating between LIP and sick leave.</td>
<td>The agreement (Kappa) of WOC in unchanged conditions (ERI) was moderate/substantial in both instruments. Perceived negative changes in working conditions (ERI) significantly yielded higher WOC, but not for all dimensions in the original instrument.</td>
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<td>Conclusions</td>
<td>Whenever possible, implementation of the original instrument is suggested.</td>
<td>Sleep disturbances and fatigue are consequences of ERI. The results can not verify that those who have high WOC are more vulnerable to ERI.</td>
<td>High ERI is associated with a situation characterized by being locked-in within an occupation and/or at a workplace. The results thereby support the theoretical model of effort-reward imbalance.</td>
<td>WOC represents a relatively stable individual factor under stable conditions. Negative changes in perceived working conditions (ERI) affect WOC negatively. The two instruments are highly correlated. The results suggest that WOC also represent an outcome from exposure of ERI and thereby a common reaction to a stressful situation.</td>
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</table>
Study populations

The WOLF study, papers I, II and IV

Work, Lipids and Fibrinogen (WOLF) is a cohort study that was initiated with the main objective to investigate the relationship between psychosocial work conditions, biological risk factors for coronary heart disease and coronary heart disease incidence and mortality. Later, other health outcomes have been targeted. The baseline examinations started in 1992 in Stockholm and were extended in 1996 to the counties of Västernorrland and Jämtland. The two parts were designated WOLF-s and WOLF-n and included 5,698 and 4,715 participants, respectively. In total, it comprised employees from approximately 60 companies served by 33 occupational health units (OHS). They were offered a health examination from the OHS and were asked to fill in a questionnaire. The data collection took place between 1992 and 1995 for WOLF-s and in between 1996 and 1998 for WOLF-n. The overall participation rate was 82%. The follow-up study, WOLFF, included only participants from Västernorrland and Jämtland. The subjects who were employed by the participating organizations were asked to answer to the WOLF questionnaire, and were offered a health examination by the OHS. Those who were not still employed by a participating organization were offered to participate by mail. The follow-up response rate was 77%, (67 persons were either deceased, had emigrated or were lost to follow-up), leaving 3,637 participants in the database. Time between baseline and follow up was, on average 60, months. Paper I and paper II used data only from the baseline study, while paper IV used data from both studies. The original instrument of extrinsic effort and reward was introduced late in the base-line study and was answered by 1174 subjects. There is no information on which subjects, who got this version.

The SKA study, paper III

The SKA study (sick leave, culture and attitudes) was a cross-sectional study with the principle aim to study regional differences in attitudes towards sick leave and the social insurance system. To study other possible underlying explanations for regional differences, broader questions about working conditions were asked, including questions about being “locked in” and about psychosocial stress expressed as effort-reward imbalance. The study was carried out by Statistics Sweden
on behalf of the Social Insurance Agency. The SKA study was composed of four questionnaires addressing: 1) a stratified random sample of the general population, 2) physicians, 3) supervisors in companies and public authorities, and 4) the employees in the Social Insurance Agency responsible for management and compensation of illness in the working population. The latter group constituted the study sample. The data were collected by a postal questionnaire in May 2005.

Study designs and statistical analysis

Wolf-study papers I, II and IV

Paper I used a cross-sectional design with data from the baseline WOLF-n study, and addressed the agreement between the original and the approximate questionnaire for extrinsic effort and reward. The study group was therefore restricted to those who had answered the questionnaire, which contained the original instrument as well as the approximate 905 men and 269 women. The analysis was confined to the group of 655 men and 178 women for whom data were complete. Ten proxy questions had been constructed from questions in the existing questionnaire (see appendix 4). For seven of the original items, there were no similar proxy questions. Each of the proxies was tested to the corresponding question in the original questionnaire by Kappa-analysis. The correlation between the indexes in the respective instruments, effort and reward, and the quotient, ERI was tested by Pearson’s correlation.

Paper II used cross-sectional data from the same sample and addressed associations between the components of the ERI model and sleep disturbances and fatigue. Those with complete answers according to the questions at issue were 789 men and 214 women. To estimate the outcome variables, sleep disturbances and fatigue, the Karolinska Sleep Questionnaire was used. From a factor analysis with varimax rotation, two factors of disturbed sleep and fatigue were created. Based on the literature, the uppermost quintile was defined as the group affected by sleep disorders and by fatigue. A factor analysis was also conducted on the questionnaires for ERI and WOC to evaluate the psychometric properties of the instruments. The indices of Effort, Reward, and WOC were divided into quartiles of exposure, as was the quotient between effort and reward. Chi-square test and Mantel-Haenszel test for trends were used to analyse the frequencies of sleep disorders and fatigue in
relation to the exposure mentioned above. Cox regression was used to
calculate the prevalence ratio (PR) for the respective outcome. The time
variable was given the value 1 according to a method suggested by Lee
(Lee and Chia 1993). To test statistical significance for additive
interaction between WOC and ERI, the confidential interval for synergy
index was calculated based on the results of logistic regression,
controlled for age, socioeconomic position and educational level.

In Paper IV cohort data from the baseline study WOLF-n as well as
from the follow-up WOLFF were used to examine the stability over time
of the personal dimension in the ERI model, WOC, and its
responsiveness for perceived changes in working conditions. The group
was composed of those who had answered the original ERI
questionnaire in the baseline study as well as at follow up. The follow-
up rate was 73% in this sample. The analyses were conducted on the
group with complete answers: 455 men and 114 women. There were no
significant differences between men and women according to the WOC
and ERI at baseline as well as at follow up. Therefore, men and women
were analysed together. Pearson’s Chi-square and Mann-Whitney test
were performed to test differences between men and women. Percent
agreement (kappa) was used for analysis of agreement between the
baseline and the follow up score for WOC, dichotomized at the upper
quartile. The kappa coefficients were evaluated on the basis of suggested
reference values (Landis and Koch 1977). To test the significance
of changes in the different subscales of WOC among those who had
experienced perceived negative changes or no changes in work
conditions (ERI), Wilcoxon’s test of related samples was performed.
Correlations between the present instrument with the original and its
subscales were tested by Spearman’s correlation.

The SKA-study, paper III

In paper III, all employees in the public Social Insurance Agency
responsible for management and compensation of illness in the working
population were selected as the study group. The study analysed the
relationship between situations characterized by perceiving being in a
LIP within an occupation and/or a workplace and ERI and also the
relationship among exposures to LIP, ERI and self-reported sick leave.
The study group comprised 5700 individuals in total, 4802 women and
898 men, aged 20–69 years. The analyses were performed for those with
complete data: 2951 women and 534 men. Test of Linear trend was used to analyse frequencies of sick leave, extrinsic effort, reward, and effort/reward ratio in relation to being in a LIP. Chi-square was used to test the relationship between the highest quartile of ERI and being in a LIP, and to test differences between men and women. Multiple logistic regression was used to calculate the odds ratio (OR) for ERI and sick leave using two models. One model concerned only LIP and ERI, where LIP was exposure and ERI was outcome and was controlled for age and education. To analyse the association between LIP and ERI as predictors and sick leave and to test mediation of ERI on the association between LIP and sick leave, two additional regressions were conducted. In the first regression (Model I), only LIP and sick leave were included. In the second regression (Model II), both LIP and ERI were included as independent variables. Both models were controlled for age. To fulfil the requirements for mediation, the following conditions must hold: 1) the independent variable (LIP) must affect the mediator (ERI) (see the above paragraph) 2) the independent variable (LIP) must be shown to affect the dependent variable (sick leave; Model I), and 3) the mediator (ERI) must affect the dependent variable (sick leave; Model II). If the regression coefficient for LIP was reduced in the second step, evidence of mediation was indicated (Baron and Kenny 1986). The significance of the mediating effect was tested by comparing the regression coefficients using the formula $Z = d/s(d)$, where $d = B_{\text{model I}} - B_{\text{model II}}$, and $s(d)$ is the correlation coefficient for the independent variable and the mediating variable multiplied by the standard error for the independent variable in the full model (Clogg, Petkova et al. 1995).

**Instruments**

**Instruments of the ERI model**

In paper I, the original questionnaire, as well as a proxy instrument of extrinsic effort and reward, was used (See appendix 1). For ten out of 17 questions, similar items were constructed from the questionnaire. The original method to classify exposure in the original questionnaire was used; i.e., each question in the 4-graded Likert scale was dichotomised between 2 and 3. In the proxy instrument, different dichotomisations were made.
In paper II, the original 17-item questionnaire of extrinsic effort and reward (ERI) was used together with the present 6-item instrument for measure of WOC (see appendix 2). The coding for ERI was made according to the present recommendations by Siegrist, Starke et al. (2004). The sum score was calculated. In the WOC instrument, one question was excluded: “If I postpone something that I was supposed to do today I’ll have trouble sleeping at night” as it also represented the outcome. Following items were used: “I get easily overwhelmed by time pressure at work”, “As soon as I get up in the morning I start thinking about work problems”; “When I get home, I can easily relax and ‘switch off’ work”; “People close to me say I sacrifice too much for my job”; and “Work rarely let me go, it is still on my mind when I go to bed”. A sum score was computed based on the four-point Likert-scale (strongly disagree (1); disagree (2); agree (3); strongly agree (4); the coding of item 3 was reversed). Those who were in the highest quartile in the respective scale were considered to be exposed.

Paper III used a shortened, tested version of extrinsic effort and reward, provided by Siegrist. The questions that were used are presented in appendix 1. The coding was similar with paper II.

Paper IV used the original 29-item questionnaire of WOC as well as the shortened, currently recommended six-item version (see appendix 2). The original questionnaire of extrinsic effort and reward was used as exposure variables. The coding was similar as in paper II.

Other instruments
Assessing disturbed sleep
Disturbed sleep was used as the dependent variable in Study II and was assessed by the Karolinska Sleep Questionnaire (KSQ) (Kecklund and Åkerstedt 1992; Åkerstedt, Knutsson et al. 2002). The questionnaire contains 13 items originally aimed at measuring three dimensions of disturbed sleep: sleep quality, impaired awakening and fatigue during the day. In this study, two distinctive factors were constituted from the factor analysis, sleep disturbance and fatigue. Based on several studies (Chen 1986; Pawlikowska, Chalder et al. 1994; Loge, Ekeberg et al. 1998; Bultmann, Kant et al. 2002; Ohayon 2002; Sharpe and Wilks 2002;
the highest quartile was chosen as cases for the analysis.

Assessing “LIP”

The situation of being in a LIP in a occupation or in a workplace was assessed by four seven-graded questions;

1) How do you like your occupation? (“Not at all” to “Very much)
2) How are your opportunities to find employment in another occupation? (“No possibilities” to “Good possibilities”) 
3) How do you like your present workplace? (“Not at all” to “Very much)
4) How are your opportunities to change workplace? (“No possibilities” to “Good possibilities”) 

Each question was dichotomized between 4 and 5; 1–4 were judged to be exposed. A lower cut-point returned too few exposed participants. If the respondents were judged to be exposed according to the first two questions, they were considered to be locked into their present occupation; if exposed with regards the latter two, they were considered to be locked in to their workplace. If both, they were considered being “doubly locked-in”.

The original questions concerning the LIP, are somewhat different (Aronsson and Göransson 1999; Aronsson, Dallner et al. 2000). In the original instrument topic is covered by two questions: 1) Today, you work at (work place, company), is that a work place you wish to work at in the future? 2) Today, you work as (occupation), is that an occupation you wish to have in the future? In discussions with the SKA project, the combination of the degree the respondent liked their work place/occupation and the degree of possibility to change was judged to better describe the LIP.

Methodical issues

Control variables

In all analyses in this thesis, controlling variables are confined to age, sex, educational level and/or socioeconomic position.
**Interaction**

The ERI model states that people characterised as being WOC are at increased risk of strain from non-symmetric exchange (Siegrist, Starke et al. 2004). It suggests that WOC generates an effect modification (interaction) of the relationship between exposure for ERI and health outcome. According to Rothman (1986), biological interaction refers to a situation when two risk factors cooperate in the causal mechanism leading to a health outcome. When the factors interact in synergy, the effect of simultaneous exposure for the two risk factors exceeds the sum of the effects of exposure for the two risks separately (additive interaction). In study II, synergy (interaction) between WOC and ERI was tested in relation to sleep disturbances and fatigue.

**Ethics**

Studies I, II and IV were approved by the ethical committee at the Karolinska Institutet. For approval of the application, informed consent was a prerequisite. In study III, a multi-disciplinary group of researchers compiled the questionnaires and analysed the results. The Swedish Statistical Central Bureau (SCB) was involved in the sampling procedure and in the ethical and juridical considerations, distribution of questionnaires, data registration, analysis of missing values and statistical calculations. Informed consent was obtained from the respondents by means of a letter that accompanied the questionnaires.
RESULTS

Paper I

The aim of the first study was to compare the original measures of the extrinsic effort and reward dimensions in the Effort-Reward Imbalance model with approximate measures devised for the same purpose.

The kappa coefficients were evaluated as suggested by Landis & Koch (1977), with less than .20 representing slight agreement; .21–.40 fair agreement; .41–.60 moderate agreement; .61–.80 substantial agreement; and .81–1.00 near-perfect agreement. Table 2 shows that only two items for women and two items for men reach the “moderate level” of agreement, while four items for women and six for men displayed only “slight agreement”.

Table 2. Agreement (Kappa) in exposure for individual items between the original and the approximate instruments for men and women, respectively.

<table>
<thead>
<tr>
<th></th>
<th>(% Kappa)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men (n=655)</td>
<td>Women (n=178)</td>
<td></td>
</tr>
<tr>
<td>Time pressure</td>
<td>.40</td>
<td>.58</td>
<td></td>
</tr>
<tr>
<td>Responsibility</td>
<td>.03</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>Overtime</td>
<td>.32</td>
<td>.34</td>
<td></td>
</tr>
<tr>
<td>Physical demands</td>
<td>.46</td>
<td>.50</td>
<td></td>
</tr>
<tr>
<td>Increased work</td>
<td>.08</td>
<td>.17</td>
<td></td>
</tr>
<tr>
<td>Respect from superior</td>
<td>.16</td>
<td>.24</td>
<td></td>
</tr>
<tr>
<td>Support</td>
<td>.09</td>
<td>.14</td>
<td></td>
</tr>
<tr>
<td>Unfair treatment</td>
<td>.06</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td>Undesirable change</td>
<td>.20</td>
<td>.25</td>
<td></td>
</tr>
<tr>
<td>Fear of job loss</td>
<td>.25</td>
<td>.23</td>
<td></td>
</tr>
</tbody>
</table>

Pearson’s correlation between the two effort-reward ratios was .50 for men and .62 for women.
The conclusions were that, whenever possible, the original instrument should be used.

**Paper II**

The aim of study II was to investigate the validity of the ERI model in relation to disturbed sleep and fatigue. This included 1) studying the internal validity of the ERI questionnaires included in the model (data not presented), 2) analysis of associations between sleep-disturbance and fatigue in relation to unfavourable situations described by the ERI model, 3) analysis of dose-response associations and possible threshold effects, and 4) analysis of whether there is an additive interaction between overcommitment and ERI.

Exposure for high effort, low reward, unfavourable effort/reward ratio and overcommitment showed a clear dose-response relationship with sleep disturbances and fatigue (Table 3). Although women generally had a higher prevalence of sleep disturbances and fatigue than men, the same pattern was seen. A palpably increased risk was demonstrated between quartile three and four for all dimensions regarding sleep disturbances as well as fatigue, indicating a threshold effect. The pattern was same for men and women, albeit on higher levels for women. Cox regression, with adjustment for age, socio-economic group and educational level yielded similar results. For men, the strongest association was seen between high over commitment and fatigue. For women, high extrinsic effort, high ERI and sleep disturbances and low reward and fatigue yielded the most obvious association.
Table 3. Percentage affected by disturbed sleep and fatigue among men and women with different levels of exposure to high extrinsic effort, low reward unfavourable effort/reward ratio and overcommitment.

<table>
<thead>
<tr>
<th></th>
<th>1st quart</th>
<th>2nd quart</th>
<th>3rd quart</th>
<th>4th quart</th>
<th>Linear trend p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong> n=789</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturbed sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High effort</td>
<td>13.3</td>
<td>11.7</td>
<td>13.5</td>
<td>18.8</td>
<td>.17</td>
</tr>
<tr>
<td>Low reward</td>
<td>7.5</td>
<td>15.9</td>
<td>14.0</td>
<td>19.3</td>
<td>.003</td>
</tr>
<tr>
<td>ER ratio</td>
<td>12.6</td>
<td>12.8</td>
<td>12.1</td>
<td>19.3</td>
<td>.082</td>
</tr>
<tr>
<td>WOC</td>
<td>9.2</td>
<td>13.4</td>
<td>13.9</td>
<td>21.0</td>
<td>.001</td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High effort</td>
<td>11.5</td>
<td>11.7</td>
<td>14.3</td>
<td>21.3</td>
<td>.008</td>
</tr>
<tr>
<td>Low reward</td>
<td>9.0</td>
<td>13.5</td>
<td>14.5</td>
<td>20.3</td>
<td>.002</td>
</tr>
<tr>
<td>ER ratio</td>
<td>9.6</td>
<td>12.8</td>
<td>10.1</td>
<td>24.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>WOC</td>
<td>5.8</td>
<td>12.4</td>
<td>16.6</td>
<td>23.7</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Women</strong> n=214</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturbed sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High effort</td>
<td>10.9</td>
<td>20.4</td>
<td>22.6</td>
<td>41.9</td>
<td>.001</td>
</tr>
<tr>
<td>Low reward</td>
<td>17.2</td>
<td>19.6</td>
<td>18.5</td>
<td>37.3</td>
<td>.025</td>
</tr>
<tr>
<td>ER ratio</td>
<td>11.1</td>
<td>20.8</td>
<td>15.1</td>
<td>44.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>WOC</td>
<td>13.0</td>
<td>20.8</td>
<td>24.6</td>
<td>40.0</td>
<td>.002</td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High effort</td>
<td>18.2</td>
<td>18.5</td>
<td>29.0</td>
<td>39.5</td>
<td>.009</td>
</tr>
<tr>
<td>Low reward</td>
<td>10.3</td>
<td>21.6</td>
<td>20.4</td>
<td>52.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ER ratio</td>
<td>18.5</td>
<td>9.4</td>
<td>30.2</td>
<td>44.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>WOC</td>
<td>18.8</td>
<td>16.7</td>
<td>28.1</td>
<td>45.0</td>
<td>.003</td>
</tr>
</tbody>
</table>

The potential interaction between work-related overcommitment and ERI was investigated according to the criterion of additivity of effects. Table 4 shows the estimated odds ratios for different combinations of ERI ratio and over commitment with regard to disturbed sleep and fatigue when dichotomised at the fourth quartile. Interaction was demonstrated only for women with respect to disturbed sleep; however this interaction was not significant.
Table 4  Adjusted odds ratio regarding sleep disturbance and fatigue among men and women exposed to different combinations of effort reward ratio and work-related overcommitment. The exposure variables were dichotomised at the fourth quartile. Adjustments made for age, socio-economic group and education.

Men (n=789)

<table>
<thead>
<tr>
<th>Overcommitment:</th>
<th>Disturbed sleep</th>
<th>Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>ER ratio:</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>1 (497)</td>
<td>2.88 (95)</td>
</tr>
<tr>
<td>High</td>
<td>2.06 (106)</td>
<td>2.84 (91)</td>
</tr>
<tr>
<td></td>
<td>2.88+2.06-1&gt;2.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No interaction</td>
<td></td>
</tr>
</tbody>
</table>

Women (n=214)

<table>
<thead>
<tr>
<th>Overcommitment</th>
<th>Disturbed sleep</th>
<th>Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>ER ratio:</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>1 (146)</td>
<td>1.45 (14)</td>
</tr>
<tr>
<td>High</td>
<td>2.71 (28)</td>
<td>3.50 (26)</td>
</tr>
<tr>
<td></td>
<td>1.45+2.71-1&lt;3.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interaction (ns)</td>
<td></td>
</tr>
</tbody>
</table>

One conclusion from the study was that the dimensions of overcommitment, extrinsic effort, reward, and effort/reward ratio, when analysed separately, were associated with sleep disturbance and fatigue. In contrast, the results could not verify that those who have the critical coping behaviour of overcommitment are more vulnerable to ERI with regard to sleep disturbances and fatigue as outcome variables. The results suggest that there is a dose–response association and a possible threshold-effect between the third and fourth quartile of the different dimensions of the ERI model. Consideration, however, has to be given to the cross-sectional design. The ERI model appeared to be an important tool to detect exposures in working life, vital to public health.
Paper III

The aim was to study the relationship between a situation characterized as being in a “locked-in” position (LIP) in occupation and/or place of work, effort-reward imbalance (ERI) and long-term sick leave.

High satisfaction with occupation and workplace and a good possibility of changing places of work show strongly negative associations with ERI (fig. 3), while the possibility of changing occupations does not show any association. The results according satisfaction with occupation and place of work demonstrate a distinct dose-response association.

Figure 3 Percentage of men and women in the highest quartile of ERI in relation to satisfaction with occupation or place of work, and the possibility of changing present occupation or place of work (n=2951)

The logistic regression analysis showed a strong association between LIP within a place of work and ERI (for women OR=3.28, 95% CI 2.65–4.07, and for men 2.74 95% CI 1.75-4.30). Also LIP within an occupation resulted in a risk for high ERI (OR=1.96 95% CI 1.57-2.41 for women, and for men 1.92 95% CI 1.22-3.03). The logistic model included age and education.
When treated independently, ERI (OR=1.40 95% CI 1.15-1.70) and LIP (see Table 5) concerning occupation and place of work, respectively, were associated with increased risk for sick leave in women. The test of mediation of ERI was conducted on women only due to having few male subjects with a sick leave period. The analysis showed significant mediation on the association between LIP and sick leave (see Model II in Table 5).

Table 5  Odds ratios (OR) for at least one sick leave period of three weeks or more among women (n=2951) in relation to being in a LIP within occupation and place of work, respectively, controlled for age. Z-value for ERI as a mediating factor between respectively LIP and sick leave.

<table>
<thead>
<tr>
<th>Model</th>
<th>Studied independent variables</th>
<th>Odds ratio (95% CI)</th>
<th>Z-value for mediation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model I</td>
<td>LIP (occupation)</td>
<td>1.48 (1.12-1.86)</td>
<td></td>
</tr>
<tr>
<td>Model II</td>
<td>LIP (occupation) and ERI</td>
<td>1.37 (1.08-1.75)</td>
<td>2.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.32 (1.08-1.61)</td>
<td></td>
</tr>
<tr>
<td>Model I</td>
<td>LIP (place of work), and ERI</td>
<td>1.88 (1.50-2.36)</td>
<td></td>
</tr>
<tr>
<td>Model II</td>
<td>LIP (place of work), and ERI</td>
<td>1.76 (1.39-2.23)</td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.23 (1.00-1.51)</td>
<td></td>
</tr>
</tbody>
</table>

One conclusion was that high ERI is associated with a situation characterized by being locked-in within an occupation or/and within a place of work. The results thereby supported the theoretical model of Effort-reward imbalance. High ERI and being locked in were associated with long-term sick leave. The result suggests that ERI is a potential mediator of the association between being locked in and sick leave.

**Paper IV**

The aims of this study were to compare stability in perceived unchanged working conditions and the reactivity in changed working conditions in Work-related overcommitment (WOC), as measured by the original and by the present, shortened questionnaires and to analyse the comparability of the two instruments.
The agreement (Kappa) between the dichotomized WOC at t₁ and t₂ was in the borderland between moderate and substantial (Landis and Koch 1977) for both the present and the original instruments, at .61 and .60 respectively.

When measured with the present WOC instrument, those who had improved their work situation (ERI) got a reduction in WOC (p=.020), whereas those who perceived a negative change considerably increased their WOC (p<.001). The group that remained in the same tertile of ERI had no significant change. Figure 4 demonstrates changes in present WOC in relation to changes in ERI.

Figure 4 Changes in the mean of WOC, measured by the present instrument, related to changes in ERI (tertiles t₁). Men and women (n=569)

Among those who perceived a negative change in their working conditions (ERI), there was significant increase in WOC in both instruments; in the original instrument; increases mainly derived from the dimension “inability to withdraw from work obligations”.

“Disproportionate irritability” also rose significantly, while “need for approval” and “competitiveness” did not significantly change (Table 6).
Table 6  WOC at t₁ and t₂ in the present WOC 6-item and the original 29-item instrument and subscales for subjects with perceived impaired working conditions (n=569). Wilcoxon’s signed ranks test.

<table>
<thead>
<tr>
<th></th>
<th>Mean t₁</th>
<th>Mean t₂</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present WOC instrument (6 items)</td>
<td>10.1</td>
<td>11.7</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Original WOC instrument (29 items)</td>
<td>59.7</td>
<td>61.1</td>
<td>.013</td>
</tr>
<tr>
<td>Need for approval (6 items)</td>
<td>14.4</td>
<td>14.4</td>
<td>(NS)</td>
</tr>
<tr>
<td>Competitiveness (6 items)</td>
<td>11.3</td>
<td>11.2</td>
<td>(NS)</td>
</tr>
<tr>
<td>Disproportionate irritability (8 items)</td>
<td>16.2</td>
<td>16.5</td>
<td>.033</td>
</tr>
<tr>
<td>Irritability to withdraw from work (9 items)</td>
<td>17.8</td>
<td>19.0</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

The correlation between the present and original WOC instrument was high, .77, but the correlation between the present instrument and the respective dimensions of the original WOC measure varied depending on how many items they contributed to the present instrument: “inability to withdraw” (.91), “disproportionate irritability” (.58), “need for approval” (.50), and “competitiveness” (.39).

WOC was considered to be reasonably stable in unchanged conditions. Negative changes in perceived working conditions affected WOC negatively in the present as well as the original measure of WOC. The correlation between the shortened WOC instrument and the original, comprehensive instrument was high. The results suggest that changes in WOC may also represent an outcome from change exposure to ERI and, thereby, a common reaction to a stressful situation.
DISCUSSION

The ERI model, one of the most influential stress models, has shown strong explanatory values for a large number of harmful health outcomes (Tsutsumi and Kawakami 2004; Siegrist 2005; van Vegchel, de Jonge et al. 2005). The model has been judged to be an important tool for understanding stress in working life (Kasl 1996). The ERI model has been developed since it first was presented, and the model construct as well as definitions, instruments, analysis and application have been changed. The fundamentals upon which the model builds as well as the applications and analysis are rarely discussed. In the following section, some of the research questions related to the construct and use of the model will be discussed as well as the outcomes of sleep disturbances and fatigue. Later, some other questions concerning methods and suggestions for future research will be discussed.

Use of approximate instruments – study I

The ERI model is a relatively new stress-theoretical model, as compared to the DC model. Since the ERI was first presented, researchers have wanted to apply the model to older, large, and well-reputed studies such as the Whitehall II and the SHEEP (Stockholm HEart Epidemiology Programme) studies, where the original instrument was not included. Therefore, approximate instruments have been developed. In the WOLF questionnaire, both the original instrument and a proxy instrument were included allowing an opportunity to compare the approximate instrument for measuring ERI, (used in the SHEEP study) (Peter, Alfredsson et al. 1998), which was collected for the major part of the respondents in WOLF, to the original instrument, introduced late in the WOLF study.

Paper I illustrates large disparities between formulations and scaling of the respective items in the both instruments (See appendix 4), and the agreement (Kappa) between single items was mostly very low. The correlation between the two ERI scales, however, was reasonable. But it is convenient to mention that the compared ERI scales only consisted of the ten comparable items. The approximate instrument had fewer items about reward, especially about security/career opportunities, the dimension that Siegrist (1996a) emphasis as a crucial factor. In an
editorial, Bourbonnais (2007) raised the general issue of using approximate or shortened questionnaires derived from validated instruments and argued for the necessity to investigate construct validity and the consequences of using only parts of validated scales. In my experience, articles that use approximate or shortened questionnaires frequently do not include thoroughly described instruments with clear wording and reply scales in the article or in an appendix. That is a prerequisite for giving the reader a possibility to compare the approximate instrument with the original.

The value of examining the agreement between scales can of course be questioned. Several studies have shown good predictive value using approximate instruments. Two arguments can be raised against the appropriateness of using instruments not validated towards the original scales. Firstly, it is not clear what one measures, especially if the main focus is altered, e.g., if the dimension security/career opportunities in the example above is not stressed to the same extent as in the original instrument. Secondly, the approximate instrument may complement to the original and provide new perspectives worth studying.

In general, there is no reason to avoid using approximate instruments, as they may provide opportunities to explore available data sets, but interpretations should be performed with caution and questions and scales used should be thoroughly presented. Pilot studies on the agreement between original and approximate instruments are desirable. At present, according to ERI, when the ERI questionnaire is included in many studies, there is no reason to use approximate instruments.

**Interaction between ERI and WOC – study II**

The relationship between ERI and WOC is not clearly defined and has been expressed in various ways. According to Siegrist et al. (2004), the highest risk of stress-related diseases is expected in individuals characterised by the co-manifestation of ERI and WOC. Kuper et al. (2002) considered that people with overcommitment will find the discrepancy between efforts and rewards particularly stressful. It has also been stated that people characterised as being WOC are at increased risk of strain from non-symmetric exchange
(Siegrist, Starke et al. 2004). The first statement can be interpreted such that people who simultaneously are exposed to two different risks have a higher risk as compared to those with a single exposure. It seems like a matter of course that two complementary risk factors result in a higher risk than only one. The following statements instead indicate that individuals characterised as having the WOC coping behaviour, are especially vulnerable to ERI. This interpretation is made in this thesis, in line with van Vegchel et al. (2005) who have designated this condition as the interaction hypothesis.

If WOC interacts in synergy with ERI, the increased risk of simultaneous exposure to both risk factors should exceed the sum of the increased risk for the two risks separately (additive interaction) (Rothman 1986). In an extensive review of 45 empirical studies, 10 tested the interaction hypothesis (van Vegchel, de Jonge et al. 2005) but only two showed interactions, at least in some respects. For example, in one of these, statistically significant additive interaction was only seen in relation to job dissatisfaction but not according to emotional exhaustion, psychosomatic complaints or physical symptoms (de Jonge, Bosma et al. 2000).

In paper II the interaction between ERI and WOC was tested with respect to sleep and daytime fatigue, but no such effect was found (Fahlén, Knutsson et al. 2006). In total, there is no strong evidence for the idea that WOC and ERI interact. Since the interaction hypothesis is rarely tested and predominantly without significant interaction, there a preclusion to draw strong conclusions with respect to the support of this hypothesis (van Vegchel, de Jonge et al. 2005). Therefore, it is important to discuss the model construct. The discussions concerning the DC model can act in a parallel. Kasl claims that the evidence for that “demands” and “decision latitude” act in synergy “can be characterized as somewhere between limited and unclear”; furthermore “Instead of testing the model, investigators should still explore possible useful variations on the model and should be encouraged to include other dimensions (as additive or interactive influences)” (Kasl 1996 p.49).
Association between LIP and ERI – study III

According to the expectancy value theory, individuals will likely act to minimize or dismiss high-cost/low-gain conditions by changing jobs or by reducing their efforts (Schönpflug and Batmann 1989). Contrary to this theory, Siegrist (1996a) points out three situations when this assumption is not valid: 1) in a situation with few alternatives on the labour market and where individuals are at risk of being laid off or facing downward mobility; 2) when people perceive opportunities to compete for promotion by extra work and additional responsibilities; and 3) when WOC is present.

A situation characterized as LIP corresponds to the situation described by Siegrist (1996a), who suggested that individuals have to stay in non-desirable situations because there are few alternatives on the labour market or from the risk being laid off or facing downward mobility. In paper III, the hypothesis that LIP is associated with ERI was tested, which had not been made earlier, and the result supported the ERI model in this respect. The results also suggested that ERI has a mediating effect between LIP and sick leave, thereby indicating a causal pathway. The results suggest that action plans to reduce sick leave should include efforts to facilitate changes of place of work and occupation and to assure well-functioning economic security for those being in intermediate stages between jobs. The weight of evidence has limitations by the cross-sectional design, which does not make it possible to judge the direction of the association with certainty.

Stability and reactivity in the WOC dimension – study IV

The WOC dimension has been shown to be an independent risk factor for ill health and diseases, although the results are not consistent (e.g., see van Vegchel, de Jonge et al. 2005). The relationship between ERI and WOC is not explicitly expressed and has been depicted in alternative ways. Peter and Siegrist (1999) claim, that in situations characterised by ERI, individuals characterized by overcommitment will exaggerate their efforts because of their desire for approval and esteem. “Need for control” (the 44 item primordial scale) has, however, been stated to be rather stable over time, and, thus, “[does] not merely reflect transient subjective states related to the situational conditions under study” (Siegrist, Peter et al. 1990, p. 1128). According to Peter and
Siegrist (1999), the coping pattern of WOC was introduced to account for sustained strain reactions in persons exposed to ERI. According to Peter, there is no explicit assumption on how the activation of WOC, which requires efforts, translates into the observed WOC. People scoring high on the WOC scale overestimate stress produced by low rewards due to increased reward expectations, and they should over- or underestimate stress resulting from efforts depending on the phase in the coping career they have reached (cf. Matschinger, Siegrist et al. 1986). He also states that these aspects of WOC have never been systematically tested (personal communication Richard Peter 080207).

In the first version of the ERI model, WOC (intrinsic effort) was considered to be one dimension of the effort concept, considered jointly with the extrinsic effort dimension. Based on the evidence of intrapersonal stability over time (see above), WOC later was considered as a psychological risk on its own (Siegrist, Starke et al. 2004) In paper IV, the stability in unchanged, and reactivity in perceived changed working conditions in WOC were analysed, as measured by the present and the original questionnaires. While WOC was rather stable in unchanged conditions, perceived positively or negatively changes in ERI corresponded to changes in WOC. The increased WOC in perceived negative change, as measured by the original instrument, was mainly derived from the dimension “inability to withdraw from work obligations”. “Need for approval” and “Competitiveness” did not show any changes, which indicate that these dimensions are more stable factors (Fahlén, Knutsson et al. In manuscript). The results were in line with Tsutsumi et al. (2002), who showed that “stressful organizational changes” affected WOC and ERI negatively. In that study, the 29-item WOC questionnaire was used, but it can be noted that neither “need for approval”, nor “competitiveness” increased significantly with the changes they judged to be the most “intense stress experience”.

The correlation between the shortened WOC instrument and the original, comprehensive instrument was high, indicating that both, to a great extent represent similar coping behaviour.

The role of the WOC dimension in the ERI model is far from clear. The results from paper II show that WOC and ERI separately represent risk factors for sleep and fatigue, while no interaction effect was found.
The results from paper IV suggest that changes in WOC also may represent an outcome from changed exposure to ERI and, thereby, a common reaction to a stressful situation. One possibility, worth studying, is, if individuals having a coping behaviour characterized of “need for approval” and “competitiveness”, two of the dimensions in the original WOC, in a situation where ERI is present, increase their irritability and/or experience difficulties to withdraw from work. Other conceivable relationships between ERI and WOC should also be taken in consideration, e.g., that WOC may act as a mediator between ERI and health outcomes, or if ERI is a mediator. Van Vegchel et al. (2005) claims that the WOC dimension possesses an erratic role in the ERI model Studies to clarify the role of the WOC dimension are needed. Longitudinal studies are desirable to provide possibilities to analyse causal pathways between ERI, WOC and ill-health.

ERI, Sleep disturbances and fatigue – study II

Sleep disturbances and fatigue are strongly stress-related health problems (Melamed, Ugarten et al. 1999; Beurskens, Bultmann et al. 2000; Grossi, Perski et al. 2003; Harvey, Jones et al. 2003; Åkerstedt 2006), are common in the population (Bultmann, Kant et al. 2002; Ohayon 2002; Åkerstedt, Knutsson et al. 2002) and are associated with serious health risks (Gillin 1998; Schwartz, Anderson et al. 1999; Nilsson, Rööst et al. 2004; Ekstedt 2005; Gangwish, Malaspina et al. 2005; Meisinger, Heier et al. 2005). Therefore it was of interest to test stress theoretical models towards sleep disturbances and fatigue as outcomes.

In paper II, strong associations were seen between disturbed sleep and fatigue and all the dimensions of ERI, i.e., high effort, low reward, unfavourable ERI-ratio and WOC. The results are in line with other studies on ERI and sleep (Kudielka, Von Känel et al. 2004; Ota, Masue et al. 2005). There was a clear dose-response association demonstrated between the respective exposure and the outcome, and a palpable threshold effect was seen between the third and fourth quartile. Since these symptoms are frequent in the population, associated with serious health problems and are strongly stress related, the results support the usefulness of ERI and WOC to assess stress in working life. Due to the cross-sectional design it is not possible to state the direction of the causal association with certainty.
**Analysis of ERI**

The first guidelines about how to analyse recommended dichotomising the answers to single items as well as the ERI quotient. In paper I, these recommendations were followed. The motive for the recommendations was probably that the questionnaires generated data on an ordinal level, which according to statistical theory is not suitable for analysis on statistically higher levels. At the same time, it is obvious, that much of the subtle information on the intensity of the exposure is lost if data are treated in that way. Later, a sum score calculated from the items score was recommended, and this method was used in this thesis from paper II, thereby assuming the ordinal scale to be an acceptable approximation of an interval scale.

In the first guidelines, the respondent was considered to be exposed for an unfavourable ERI situation if the value of the ERI quotient was greater than 1.0. The figure 1.0 can be seen as a metaphor for balance; i.e., the denominator and nominator are of the same weight and importance, and effort and reward are in balance. There is, however, no evidence presented that effort and reward, as measured by the ERI instrument, would be in balance when the quotient is 1.0. Other possible motives for the use of 1.0 as a cut-off could be that it constitutes a level for threshold effects or that it is a purposeful limit for diagnostics or actions. Such evidence is not presented. In the first version of Paper I, agreement (Kappa) between the two instruments was analysed with this cut-off and was found to generate only slight agreement for men (.16) and fair agreement for women (.36), which according to Landis and Koch (1977), are the lowest and second lowest class. The correlation between the scales was reasonable, however, at .50 for men and .62 for women. The Kappa score for agreement between the scales was not presented in paper I. At that time, the dichotomy was under discussion in an international research group, Social Variations in Health Expectancy in Europe in the frame of European Science Foundation Scientific Programme (personal communication Anders Knutsson). Though our belief was that this dichotomy was going to be dismissed it has later been suggested that 1.0 may be useful for the comparison of several data sets (Siegrist, Starke et al. 2004). In 2002, Siegrist suggested using a ratio based on a continuous logarithmical scale, which has the
advantage of losing less information. The motive for using a logarithmical scale was to place an inverse imbalance of the same magnitude at the same distance from 1.0 (Siegrist 2002). In the major part of the analysis in this thesis, the requirements for normal distribution were not fulfilled even after transformation to logarithmic scale or other alternatives and therefore such scales were not used.

Our results (paper II) suggest that the upper quartile seems to be an appropriate point of dichotomy and that median and quartiles provide further information on level as well as distribution of ERI.

**Methodical considerations**

**Study design and study populations**

The studies II and III have cross-sectional designs. Therefore it is not possible to establish the direction of the causal associations with certainty but, longitudinal studies concerning cardiovascular diseases (Siegrist 2005; van Vegchel, de Jonge et al. 2005) indicate that there is a causal influence from ERI to stress-related health outcomes.

None of the samples in the studies are randomly selected from the work force; thus, transferring the results to the whole working force should be made with caution.

**Drop out analysis**

The original questionnaire was distributed late in the baseline study of WOLF. It is not possible to determine which subjects got this version (studies I, II and IV). Though there is no reason to assume that the drop-out is different in this group, it limits the possibility of a thorough drop-out analysis.

**Control variables**

In all analyses in this thesis, the control variables were confined to age, sex, educational level and/or socioeconomic position. Health behaviour or established biomedical risk factors are not included in the models. A discussion about the relevance of using such control variables as potential confounders is relevant according to study II, which
concerned ERI as the exposure variable and sleep disturbances and fatigue as outcomes, and study III which dealt with LIP as the exposure and ERI and sick leave as outcomes. Confounding refers to a situation where the effect of an exposure (e.g. ERI) on health outcome (e.g. sleep disturbances) is mixed with a third factor (e.g. high BMI). It can cause overestimation or underestimation of the effects and may change the direction of the effect under study. A confounder must be imbalanced between the exposure groups to be compared. A confounder must fulfil three requirements: 1) a confounder must be a risk factor for the outcome, 2) a confounder must be associated with the exposure, and 3) a confounder must not be an effect of the exposure i.e., must not represent a causal pathway between exposure and outcome (Rothman 2002).

According to Kasl (1996) there is no obvious stage of disease development that is thought to be influenced by the psychosocial work variables. It is possible that those exposure variables are not independent but, rather, they operate through established health behaviours and biomedical risk factors. Several unhealthy behaviours, e.g., excessive food intake and lack of exercise, also have a negative influence on biomedical parameters (Kasl 1996). Concerning health behaviour, the patterns are not randomly distributed across society but instead clustered in accordance to the social opportunity structure (Siegrist and Rödel 2006). There is some evidence for associations between work stress and health behaviour. In a review of 46 studies, the support was modest for a consistent association between work stress and health behaviour. The strongest association was found with regards to heavy alcohol consumption among men and being overweight (Siegrist and Rödel 2006). An interesting approach was made by Kouvonen et al. (2006), who showed a strong dose-response relationship between ERI and the number of health-risk behaviours. The considered factors were current smoking, heavy drinking, being overweight (BMI>25), and physical inactivity. Combined adverse lifestyle factors also have been shown to act in synergy (Meng, Maskarinec et al. 1999).

A recent, longitudinal study based on the Whitehall II cohort analysed causal links between work stress, health behaviours, metabolic syndrome and CHD. It was found that around a third of the effect from work stress on CHD was attributable to its effect on health behaviours and the metabolic syndrome. (Chandola, Britton et al. 2008) In this
study, the DC model was used to assess work stress. Considering that the ERI model concerns not only the work tasks but instead emphasises the reciprocity in the social exchange between the employees, colleagues and employers, it is quite conceivable that ERI to a greater extent influences behavioural patterns.

Thus, it is not clear to what extent health behaviours and biomedical markers act as confounders and to what extent they constitute causal pathways between exposure and outcome. When controlling for health habits and biomedical risk factors to estimate direct effects from the exposure, there is a risk that the total effect will be underestimated. Analysis without considering health behaviours, as in this thesis, however, must be interpreted with some caution.

**Self – reported data**

It has been discussed to what extent self-reported assessments of the psychosocial work environment reflect individual characteristics and to what extent they reflect environmental conditions.

In this thesis, analyses are not controlled for negative affectivity (NA), i.e., a tendency to experience negative emotions. If the objective work environment is the target, any factor independent of that environment that influences the measure, will act as a bias. If, instead, individual perceptions of the environment are of interest, personal characteristics are causes of the underlying construct – perception (Spector, Zapf et al. 2000). The problem that may arise from NA is particularly important when psychosocial as well as health issues are described by means of self-reports and recorded in cross-sectional studies (Theorell and Hasselborn 2005), as in studies II and III. The appropriateness of controlling for negative affectivity has been discussed. Kasl (1998) emphasises that stable traits indicating a stable level of negative affect may influence perceptions of the work environment and various outcomes and, therefore, that NA must be taken into consideration. Kasl admit, however, that there yet is no adequate direct measure of NA available. In contrast, Spector et al. (2000) claim that negative affectivity should not be controlled in job stress research, stating, “[D]on’t throw out the baby with the bath water” (Spector, Zapf et al. 2000, p. 79). They state that NA, which can
play a variety of substantive roles in the job stress process can be divided into three components: 1) a stable trait of affective disposition, 2) more transitory factors, such as mood, or 3) reactions to job stressors. They also claim there is a risk that the effects of the variables of interest are removed before they are tested towards the outcome.

Theorell and Hasseborn (2005) call attention an opposite problem: some subjects who instead complain about nothing and therefore underreport environmental and health problems.

To what extent health behaviour and NA are independent from job stressors and to what extent they thereby should be included in the analyses is not found in research literature. Since those factors not are controlled for in the analyses and since both exposure and outcome are self-reported, the effects from unfavourable conditions according to the ERI model may have been overestimated. If, however, the analyses had included these control variables, risk had ensued that true effect from exposure may have been underestimated or not detected.

**Suggestions for future research**

The ERI model includes personal as well as situational information, thereby avoiding a “black box” approach, but the role of the personal dimension, WOC, is not fully spelled out or explained, e.g., whether or not it represents a risk factor independent from ERI, to what extent it represents an outcome from ERI, or whether or not WOC acts as a mediator between ERI and health outcomes. Furthermore, there is no explicit assumption on how the activation of WOC, which requires effort, translates into the observed WOC, and these aspects of WOC have never been systematically tested. Studies to elucidate the role of WOC in the ERI model are needed. Longitudinal studies are desirable to give possibilities to analyse causal pathways between ERI, WOC and ill-health.

The instruments in the ERI model are constructed from a large number of questions thought to mirror the aspects of interest, which, after factor analysis and other tests, have been established as instruments. The factorial structure has been evaluated in several studies from different population, e.g. in Siegrist et al. (2004), resulting
in the shortened version of WOC. Nevertheless, the meaning of different assertions in the instruments could vary among different individuals depending on linguistic matters, culture, gender and social class. The meaning could also vary through the life course. Such studies should improve the understanding of the mechanisms and different patterns in outcomes, e.g., between men and women. These questions have to be addressed with qualitative methods.

One fundamental question is whether or not it is possible to use the ERI model in efforts to reduce risks for ill-health. The research concerning the ERI model lacks intervention studies. In an early pilot study, WOC was significantly reduced as a result of a stress management program in bus drivers, simultaneously targeting a reduction of levels of stressful environment (ERI) as well as the coping behaviour of WOC. (Aust, Peter et al. 1997). One large scale intervention study (n=302) addressed ERI and DC and showed a slight, but significant decrease in ERI after 12 months (Bourbonnais, Brisson et al. 2006). One imaginable reason for the shortage of intervention studies, is, that the properties of the WOC dimension are unclear. Another reason may be that ERI model emphasizes aspects of effort and reward that are difficult to modify. Kasl states; “Thus it would be of considerable interest to formulate additional hypotheses regarding the possible effective ways of redressing the imbalance” (Kasl 1996, p. 52). Formulation and testing of such hypotheses in intervention studies are of importance to increase the relevance of the ERI model, not only as a model for assessing stress, but also, as a model for improving working conditions and health.
CONCLUSIONS

- The results indicate that ERI and WOC as exposure constitute risk factors for sleep disturbances and fatigue. A palpable threshold effect was seen between quartile three and four. Since these symptoms are strongly stress related, our results support the usefulness of ERI and WOC scales to assess stress in working life.
- When approximate instruments are used, questions and scales must be presented thoroughly to facilitate comparisons and the results should be interpreted with caution. Today, there are no motives to use approximate instruments in the ERI model.
- There is no convincing evidence that ERI and WOC interact in synergy. WOC may also act as an outcome from ERI, not only as a coping strategy. Studies to clarify the role of the WOC dimension in the ERI model are desirable.
- The association between LIP and ERI suggests that LIP constitute a risk factor for ERI. The results indicate that ERI may act as a mediator between LIP and sick leave.
SVENSK SAMMANFATTNING – SWEDISH SUMMARY


Arbetsrelaterad stress har sedan slutat av sjuttiotalet alltmer blivit uppmärksammad som en viktig bestämningfaktor för ohälsa. En av de mest inflytelserika stressmodellerna är Ansträngning-belönings modellen (Effort-reward imbalance, ERI) som stipulerar att en obalans mellan ansträngning och belöning i arbetet orsakar en skadlig stress och att de som har ett särskilt coping-beteende som kännetecknas bland annat av oförmåga att dra sig tillbaka från sitt arbete (Work related overcommitment WOC) är särskilt sårbara. Modellen har visat ett starkt förklaringsvärde för många negativa hälsoutfall.

Det övergripande syftet med avhandlingen var att bidra till utvecklingen av ERI-modellen genom att utforska modellens egenskaper i relation till de teoretiska antagandena, uppbyggnad och tillämpning samt att öka kunskapen om modellens validitet.

Den epidemiologiska studie som användes i tre artiklar var WOLF-studien (WOrk, Lipids and Fibrinogen) där analyserna genomfördes på den delmängd som hade svarat på ERI-frågorna (n=1174) och som hade kompletta svar. För en artikel användes material från SKA-studien (Sjukskrivning, Kultur och Attityder) och omfattade de som arbetade med ohälsöärenden vid Försäkringskassan (n=5700) i samtliga fall användes data från frågeformulär.

Resultaten visade att ERI och WOC utgör riskfaktorer för störd sömn och dagtrötthet. En tydlig tröskeleffekt kunde skönjas mellan tredje och fjärde kvartilen. Eftersom dessa symptom är starkt stressrelaterade, gav resultaten stöd för användbarheten av ERI och WOC instrumenten för att skatta stress i arbetslivet.

Överensstämmelsen mellan enskilda frågor i orginalinstrumentet för ERI och ett approximativt var låg, medan överensstämmelsen mellan de två ERI skalorna bedömdes som rimlig. När approximativa instrument
används bör frågor och skalar presenteras utförligt för att jämförelser ska underlättas och resultaten bör tolkas med försiktighet.


En annan utgångspunkt i modellen är att en av de situationer man stannar i ogynnsamma arbetsförhållanden kännetecknade av ERI, är att man har små möjligheter att byta arbete beroende på att man har få möjligheter på arbetsmarknaden eller är utsatt för risk att bli uppsagd eller att få sämre arbete, man är ”inlåst”. Resultaten visade på en stark association mellan inlåsning och ERI och gav därmed stöd åt antagandet.

**Keywords:** Psychosocial stress, Effort-reward imbalance, Working life
REFERENCES


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Appendix 1. ERIQII

ERIQII 17Items Version 20.08.07 © J. Siegrist, University of Dusseldorf

Questionnaire II – Working Situation

The following items refer to your present occupation. For each of the following statements, please indicate to what degree it reflects your situation. Thank you for answering all statements!

ERI1  I have constant time pressure due to a heavy work load.

Disagree ............................................. [ ] (1)
Agree, but I am not at all distressed .......... [ ] (2)
Agree, and I am somewhat distressed ...... [ ] (3)
Agree, and I am distressed.................... [ ] (4)
Agree, and I am very distressed............. [ ] (5)

ERI2  I have many interruptions and disturbances while performing my job.

Disagree ............................................. [ ] (1)
Agree, but I am not at all distressed .......... [ ] (2)
Agree, and I am somewhat distressed ...... [ ] (3)
Agree, and I am distressed.................... [ ] (4)
Agree, and I am very distressed............. [ ] (5)

ERI3  I have a lot of responsibility in my job.

Disagree ............................................. [ ] (1)
Agree, but I am not at all distressed .......... [ ] (2)
Agree, and I am somewhat distressed ...... [ ] (3)
Agree, and I am distressed.................... [ ] (4)
Agree, and I am very distressed............. [ ] (5)

ERI4  I am often pressured to work overtime.

Disagree ............................................. [ ] (1)
Agree, but I am not at all distressed .......... [ ] (2)
Agree, and I am somewhat distressed ...... [ ] (3)
Agree, and I am distressed.................... [ ] (4)
Agree, and I am very distressed............. [ ] (5)

ERI5  My job is physically demanding.

Disagree ............................................. [ ] (1)
Agree, but I am not at all distressed .......... [ ] (2)
Agree, and I am somewhat distressed ...... [ ] (3)
Agree, and I am distressed.................... [ ] (4)
Agree, and I am very distressed............. [ ] (5)

ERI6  Over the past few years, my job has become more and more demanding.

Disagree ............................................. [ ] (1)
Agree, but I am not at all distressed .......... [ ] (2)
Agree, and I am somewhat distressed ...... [ ] (3)
Agree, and I am distressed.................... [ ] (4)
Agree, and I am very distressed............. [ ] (5)
ERI7 I receive the respect I deserve from my superiors.

Not applicable (no superiors) □ (0)
Agree .................................................. □ (1)
Disagree, but I am not at all distressed □ (2)
Disagree, and I am somewhat distressed □ (3)
Disagree, and I am distressed .................. □ (4)
Disagree, and I am very distressed ........... □ (5)

ERI8 I receive the respect I deserve from my colleagues.

Not applicable (no colleagues) □ (0)
Agree .................................................. □ (1)
Disagree, but I am not at all distressed □ (2)
Disagree, and I am somewhat distressed □ (3)
Disagree, and I am distressed .................. □ (4)
Disagree, and I am very distressed ........... □ (5)

ERI9 I experience adequate support in difficult situations.

Agree .................................................. □ (1)
Disagree, but I am not at all distressed .... □ (2)
Disagree, and I am somewhat distressed .. □ (3)
Disagree, and I am distressed .................. □ (4)
Disagree, and I am very distressed .......... □ (5)

ERI10 I am treated unfairly at work.

Disagree ................................................ □ (1)
Agree, but I am not at all distressed ....... □ (2)
Agree, and I am somewhat distressed ..... □ (3)
Agree, and I am distressed .................... □ (4)
Agree, and I am very distressed ............. □ (5)

ERI11 My job promotion prospects are poor.

Disagree ................................................ □ (1)
Agree, but I am not at all distressed ....... □ (2)
Agree, and I am somewhat distressed ..... □ (3)
Agree, and I am distressed .................... □ (4)
Agree, and I am very distressed ............. □ (5)

ERI12 I have experienced or I expect to experience an undesirable change in my work situation.

Disagree ................................................ □ (1)
Agree, but I am not at all distressed ....... □ (2)
Agree, and I am somewhat distressed ..... □ (3)
Agree, and I am distressed .................... □ (4)
Agree, and I am very distressed ............. □ (5)
ERI13  My employment security is poor.

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<td>Disagree ..............................................</td>
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<td>Agree, but I am not at all distressed ..........</td>
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<tr>
<td>Agree, and I am somewhat distressed ..........</td>
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<tr>
<td>Agree, and I am distressed ......................</td>
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<td>Agree, and I am very distressed .................</td>
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ERI14  My current occupational position adequately reflects my education and training.

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<td>Agree ..................................................................</td>
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<tr>
<td>Disagree, but I am not at all distressed .........</td>
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<tr>
<td>Disagree, and I am somewhat distressed ............</td>
<td>(3)</td>
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<tr>
<td>Disagree, and I am distressed ......................</td>
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<tr>
<td>Disagree, and I am very distressed .................</td>
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ERI15  Considering all my efforts and achievements, I receive the respect and prestige I deserve at work.

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<tr>
<td>Agree ..................................................................</td>
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<tr>
<td>Disagree, but I am not at all distressed .........</td>
<td>(2)</td>
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<tr>
<td>Disagree, and I am somewhat distressed ............</td>
<td>(3)</td>
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<tr>
<td>Disagree, and I am distressed ......................</td>
<td>(4)</td>
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<tr>
<td>Disagree, and I am very distressed .................</td>
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ERI16  Considering all my efforts and achievements, my job promotion prospects are adequate.

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<tr>
<td>Agree ..................................................................</td>
<td>(1)</td>
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<tr>
<td>Disagree, but I am not at all distressed .........</td>
<td>(2)</td>
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<tr>
<td>Disagree, and I am somewhat distressed ............</td>
<td>(3)</td>
</tr>
<tr>
<td>Disagree, and I am distressed ......................</td>
<td>(4)</td>
</tr>
<tr>
<td>Disagree, and I am very distressed .................</td>
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ERI17  Considering all my efforts and achievements, my salary / income is adequate.

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<tr>
<td>Agree ..................................................................</td>
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<tr>
<td>Disagree, but I am not at all distressed .........</td>
<td>(2)</td>
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<tr>
<td>Disagree, and I am somewhat distressed ............</td>
<td>(3)</td>
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<tr>
<td>Disagree, and I am distressed ......................</td>
<td>(4)</td>
</tr>
<tr>
<td>Disagree, and I am very distressed .................</td>
<td>(5)</td>
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Thank you for answering the questions!

The shortened version (Paper III) provided by Prof Siegrist included the items 1, 2, 6, 7, 11, 12, 13, 15, 16 and 18.
Appendix 2. The 29 items in the original questionnaire of WOC

Need for approval
1. I usually take criticism very serious
11. I get angry with myself when I can’t completely resolve a problem at work
13. I get especially frustrated when my work is not properly appreciated
17. I only feel successful when I perform better than I expected
18. Other people have confidence in my ability to handle difficult tasks
25. The slightest compliment really boosts my confidence

Competitiveness
2. I am fuelled by ambition?
5. I enjoy proving certain people wrong
6. Always being a little better or faster than others is sort of game to me
12. I don’t let others do my work
21. I get furious when anybody questions my competence
26. I don’t feel angry when others do better than me

Disproportionate irritability
3. Even the slightest interruption bothers me
8. I get upset with others more often than I should
9. (*) I get easily overwhelmed by time pressures at work.
14. I can get furious if someone doesn’t understand me the first time
19. I do everything possible to be in control
22. I don’t usually get annoyed when my work routine is interrupted
23. I always want more than I can get
28. I am always mentally prepared to do what needs to be done next

Inability to withdraw from work
4. If something needs to be done right I’d better do it myself
7. I can get very upset when someone keeps me from what I’m supposed to be doing
10. (*) I start thinking about work as soon as I get up in the morning.
15. (*) When I get home, I can easily relax and forget all about work.
16. (*) People close to me say I sacrifice too much for my job.
20. My private life come first, and then work
24. (*) Work is usually on my mind when I go to bed
27. Every once in a while, I like when others keep me from working
29. (*) If I put off doing something that needs to get done today, I’ll have trouble sleeping at night.

Items also included in the present version are marked with (*)
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Appendix 3

Please indicate to what extent you personally agree or disagree with these statements
Thank you for answering all statements.

<table>
<thead>
<tr>
<th>OC1</th>
<th>I get easily overwhelmed by time pressures at work.</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC2</td>
<td>As soon as I get up in the morning I start thinking about work problems.</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>OC3</td>
<td>When I get home, I can easily relax and &quot;switch off&quot; work.</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>OC4</td>
<td>People close to me say I sacrifice too much for my job.</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>OC5</td>
<td>Work rarely lets me go, it is still on my mind when I go to bed.</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>OC6</td>
<td>If I postpone something that I was supposed to do today I'll have trouble sleeping at night.</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
</tbody>
</table>
**Appendix 4.** Measures of extrinsic effort and reward used in paper I. The item number corresponds to the original instrument. To be judged as exposed for the conditions stated in the original items the respondent must be exposed and consider the conditions as distressing or very distressing.

<table>
<thead>
<tr>
<th>Original statement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extrinsic effort</strong></td>
</tr>
<tr>
<td>1. I have constant time pressure due to heavy work load.</td>
</tr>
<tr>
<td>Do you have enough time to meet the demands? Exposed if “seldom” or “never”.</td>
</tr>
<tr>
<td>3. I have a lot of responsibility in my job.</td>
</tr>
<tr>
<td>Do you have responsibility for health and safety of other people in your job? Du you have responsibility for material values or damage in your job? Do you have to make difficult decisions? Exposed, if “yes often”, or, “yes sometimes” in at least one question.</td>
</tr>
<tr>
<td>5. I am often pressures to work overtime.</td>
</tr>
<tr>
<td>How often it happens that you work overtime? Exposed if “often”.</td>
</tr>
<tr>
<td>6. My job is physically demanding.</td>
</tr>
<tr>
<td>How physically demanding do you think Your work is? 14-graded scale, Exposed if “strenuous” to “very, very strenuous.</td>
</tr>
<tr>
<td><strong>Esteem reward</strong></td>
</tr>
<tr>
<td>7. I receive the respect I deserve from my superiors.</td>
</tr>
<tr>
<td>I get praised from my superior if I made a good job. Exposed if “seldom” or “never”</td>
</tr>
<tr>
<td>9. I experience adequate support in difficult situations.</td>
</tr>
<tr>
<td>If your tasks are difficult, can you get advice and help? Exposed if “seldom” or “never”.</td>
</tr>
<tr>
<td>10. I am treated unfairly at work.</td>
</tr>
<tr>
<td>Are you involved in conflicts in your job? Exposed if “often” or “sometimes”.</td>
</tr>
</tbody>
</table>
Status control

11. I have experienced or I expect to experience undesirable change in my work situation. Are you concerned about relocation of your job? Are you concerned about job Reorganisation? Are you concerned about introduction of new technologies? Exposed if “yes” for at least one of the questions.


The question numbers refer to the original instrument.