SUBJECTIVE COGNITIVE COMPLAINTS IN THE WORKING POPULATION

The Influence of Objective Cognitive Functioning and Working Conditions

Cecilia U. D. Stenfors

Doctoral Thesis in Psychology at Stockholm University, Sweden 2013
Subjective Cognitive Complaints in the Working Population

The Influence of Objective Cognitive Functioning and Working Conditions

Cecilia U. D. Stenfors
Abstract

Cognitive functioning is important for managing work and life in general. However, subjective cognitive complaints (SCC), involving self-perceived difficulties with concentration, memory, decision making, and clear thinking are common in the general and in the working population and can be coupled with both lowered well-being and work ability. The present thesis investigated the extent to which SCC among people in the work force can be explained by objective cognitive functioning (study I & II) and working conditions (study III), utilizing samples from the working population. The potential roles of other common psychological problems which often co-occur with SCC were also investigated in studies I-III.

In **Study I**, high levels of SCC were associated with significantly poorer episodic memory performance during high executive demands and a trend was found towards poorer episodic memory, while not being associated with semantic memory. In **Study II**, high levels of SCC were associated with significantly poorer executive cognitive performance on all three executive cognitive tests used. Symptoms of depression, chronic stress and sleeping problems were found to play an important role in the relations between SCC and episodic memory during divided attention in study I and executive cognitive functioning in study II. In **Study III**, in all cross-sectional data analyses, high quantitative demands, information and communication technology (ICT) demands, underqualification in the work situation and inter-personal conflicts were positively associated with SCC, whereas social support, good resources at work and overqualification in the work situation were negatively associated with SCC. In all prospective data analyses, quantitative job demands, ICT demands and underqualification were positively associated with future SCC, including when adjusted for baseline cognitive complaints.

The findings may guide prevention of and interventions for SCC among people in the work force.

*Keywords:* Subjective cognitive complaints, cognitive functioning, declarative memory, episodic memory, semantic memory, working memory, executive cognitive functioning, psychosocial working conditions, demand-control-support model, population-based
Acknowledgements

First of all I want to thank my main supervisor Professor Lars-Göran Nilsson and my co-supervisors Professor emeritus Töres Theorell, Linda Magnusson Hanson and Gabriel Oxenstierna, for sharing your knowledge, research skills and experience and for always being supportive and enthusiastic about my work. I am also very grateful for all the freedom and responsibility you have given me in my work, in combination with your constant support. This has given me the opportunity to develop and grow as an independent researcher. It has been a pleasure working with you!

Then I would like to thank all the colleagues and friends at work who have enriched my life socially and intellectually and have been supportive during the thesis period. These include people at the Stress Research Institute, the Department of Psychology, the Institute for Stress Medicine, Stockholm Brain Institute, and elsewhere: Maria Baltzer, Malena Ivarsson, Margareta Hedner, Karin Schraml, Aram Seddigh, Martin Benka Wallén, Anna Nyberg, Johanna Schwarz, Sofia Lagergren, Julia Romanowska, Hugo Westerlund, Constanze Leineweber, Holendro Singh Chunkham, Torbjörn Åkerstedt, Aleksander Perski, Dan Hasson, Martin Hyde, Göran Kecklund, Arne Lowden, Mikael Ingre, Gustav Nilsonne, Mats Lekander, Anna Nixon Andreasson, Tina Sundelin, Giorgio Grossi, Barbara Caracciolo, Kristina Bodin Danielsson, Louise Nordensköld, Veronica Klevegren, Bosse Gigel, Annette Hedberg, Veit Kubik, Petter Marklund, Fredrik Jönsson, Johan Wilander, Jonas Persson, Marianne Jakobsson, Jesper Alvarsson, Anna Sol Lindqvist, Jelena Corovic, Joakim Norberg, Håkan Andersson, Malin Mattson, Artin Arshamian, Stina Cornell Kärnekull, Anders Sand, Nathalie Peira, Kristina Karlsson, Martin Arvidsson, Anne Richter, Helena Falkenberg, Jan Bergström, Marie Gustavsson Sendén, Lena Låstad, Mina Sedem, Jonas Olofsson, Lisa Folkeson, Hanna Kusterer, Roberto Riva, Ann-Charlotte Smedler, Maria Larsson, Torun Lindholm, Magnus Sverke, Petra Lindfors, Pehr Granqvist, Timo Mäntylä, Mats

I would also like to thank Gunilla Bohlin and Ove Almqvist for reviewing my thesis and giving valuable feedback!

To my previous psychology teachers/professors at the University of St.Andrews- Gillian Brown, Phil Winn, Barbara Dritschel, Mike Oram, Gerry Quinn, Dave Perrett, Inez Jentzsch and more- thank you for the knowledge and skills you taught, for being super cool and inspiring people, and for encouraging me to go into research!

Thanks to FAS and Afa insurance for funding that enabled this research.

Thanks also to the Swedish Research Council and Swedish National Data Service for funding my studies in quantitative methods at the Interuniversity Consortium for Political and Social Research at the University of Michigan.

Many thanks to all the people who participated in SLOSH.

To friends outside academia- thanks for being you and for enriching my life with your friendship, for all the interesting discussions, adventures and good times: Tess Sundelin, Lisa Karlsen, Andrea Rogefors, Turid Tersmeden, Susanna Nilsson, Åsa Nääv, Jodie Giles, Maja Danneman, Dusan Perovic, Tutuwa Ahwoi, Elisa Whynne-Hughes, Kim Gilson, and Martin Bojner Horwitz.

To the Osika family- thanks for your positive energy and support, Hilke and Christian, Michaela, Ingrid and Peter Friberg, Anton, Mingo, Charlotte and Alexander.
Importantly, I want to express my very special thanks to my wonderful family, for all your love and all your support throughout my life: My mother Gunilla, my father Dag, my brother Peter, my sister Camilla and my grandmother Marianne. Thanks also to Mikael, Theo, Julie, Dante, Jan, Anna-Lena, Bella, and William, who have become important family members during the last decade.

To my colleague, my friend, and my beloved partner in life, Walter Osika- I am immensely grateful for all your love and support, for all that you are and for all that we have together.

Last, I am endlessly grateful to our beloved daughter, Celine- for coming to us and filling our lives with your presence. You are the most wonderful and important that has ever happened to me.
List of studies

The present thesis is based on the following studies:


Contents

Abbreviations .............................................................................. 15
Introduction .................................................................................. 16
Background .................................................................................. 18
  SCC & cognitive functioning ....................................................... 18
    Cognitive function ................................................................. 18
    SCC ...................................................................................... 20
    SCC & cognitive functioning among elderly ............................. 20
    SCC & cognitive functioning among younger adults ............... 21
SCC & brain function ................................................................. 22
Potential causes of SCC among working adults ......................... 23
  Aspects of psychological health ............................................... 24
    Appraisal .............................................................................. 25
    Allostasis .............................................................................. 25
    Acute stress & cognition ....................................................... 26
    Allostatic load ...................................................................... 27
    Chronic stress & cognition ..................................................... 27
Other factors ................................................................................ 29
  Working conditions, mental health & SCC ................................. 29
  Other factors that can influence the relation between SCC &
cognitive functioning .............................................................. 32
General aims of the thesis ............................................................ 35
Methods ...................................................................................... 36
  The Swedish Longitudinal Occupational Survey of Health  
(SLOSH) .................................................................................... 36
    Sample, study I & II ............................................................... 37
    Samples, study III .................................................................. 38
SCC, study I-III .......................................................................... 38
Cognitive/neuropsychological measures, study I & II ................. 39
  Episodic memory ................................................................... 39
  Semantic memory ................................................................... 41
  Executive cognitive functioning ................................................. 42
Psychosocial working conditions, study III ............................... 44
Potential confounders included, study I-III ................................. 45
Abbreviations

AD  Alzheimer’s disease
DA  Divided attention
DCQ  Demand-control questionnaire
DCS-m  Demand-control-support model
FA  Focused attention
ICT  Information and communication technology
HPA  Hypothalamic-pituitary-adrenal axis
SAM  Sympathetic-adrenal medullary system
MCI  Mild cognitive impairment
PFC  Prefrontal cortex
SCC  Subjective cognitive complaints
SLOSH  Swedish Longitudinal Occupational Survey of Health
WM  Working memory
Introduction

Proper cognitive functioning is essential for adequate performance in working life, for managing life in general, and for well-being. However, self-perceived problems with cognitive functioning are rather common, both among elderly, as well as among younger working-age adults. The subjective experience of having problems with cognitive functioning is often referred to as subjective cognitive complaints (SCC), although other terms are also used in the literature (e.g. subjective cognitive impairment).

In this thesis, the subjective cognitive problems that are studied are difficulties with memory, concentration, decision-making, and thinking clearly. Approximately 10 % of gainfully working Swedes report having perceived at least one type of cognitive difficulty “often” during the last three months (Study III (Stenfors, Magnusson Hanson, Theorell, Oxenstierna, & Nilsson, 2013)).

SCC often co-occur with other common psychological health problems that belong to the major causes of sick leave (Försäkringskassan, 2013), including depression, chronic stress/exhaustion and sleeping problems (Ponds, Commissaris, & Jolles, 1997; Scholtissen-In de Braek, Hurks, van Boxtel, Dijkstra, & Jolles, 2011; Stenfors et al., 2013; Vestergren & Nilsson, 2011). SCC are also related to quality of life (Scholtissen-In de Braek et al., 2011). SCC in the frame of depressive and stress related conditions have also been described as a key factor that reduce work ability and may be problematic even in phases when other types of symptoms are reduced (e.g. (Ekstedt & Fagerberg, 2005; Slebus, Kuijer, Willems, Frings-Dresen, & Sluiter, 2008)). SCC may, thus, indicate actual cognitive deficits that require appropriate aids or interventions to handle or to improve functionality.

Although SCC may be troublesome to the individual, the relation to actual, objective, cognitive functioning is far from clear.
Surprisingly few studies have been conducted on non-elderly and working populations, where SCC may limit work-ability and be a reason for long term sick leave.

Furthermore, the role of stressors and resources in the working situation for the prevalence and development of SCC is an important aspect of understanding SCC in the work force. This knowledge could be useful for guiding preventive and intervention measures at workplaces where SCC are prevalent among the employees. Still, only a few studies have investigated the relation between SCC and working conditions.

Thus, the purpose of this thesis was to increase knowledge and understanding of SCC among individuals in the work force, in terms of their relationships to objective cognitive functioning domains, as well as their relationships to working conditions.
Background

Subjective cognitive complaints (SCC) and cognitive functioning

Cognitive functioning

“Cognitive functioning” entails many different mental operations and is generally subdivided into a range of cognitive functions, which in turn can be subdivided into different cognitive processes. The division into different cognitive functions generally stems from findings that separate cognitive functions may be somewhat exclusively affected while other functions are spared when the respective functionally associated brain regions are damaged versus intact. Although different functional brain areas and cognitive functions interact and subserve each other, different types of studies have generally supported a division of human memory into five different systems (Gabrieli, 1998). One is short-term memory, or working memory (WM), for temporary storage and manipulation of representations, also classified as an executive function (Baddeley, 2003). The other four systems are for long term storage and include episodic memory, semantic memory, procedural memory and the perceptual representation system. Working memory, episodic memory and semantic memory are classified as declarative memory systems (Tulving, 1992) as these involve the conscious awareness of memory representations, while the remaining two systems store implicit information.

The function of episodic memory is to account for memory of the personal past. It requires a conscious recollection of a previous event or episode defined in time and space. The function of semantic memory is retrieval of general knowledge and facts that is not related to time and place of a study episode. Episodic memory processing has been structurally localized to the medial-temporal lobe, including hippocampus and with supporting
pathways from executive functional networks in prefrontal cortical (PFC) regions (Kim, Valles, Picton, & Tulving, 2009; Tulving, 2002), while semantic memory functioning has been associated with the posterior cortices and left frontal regions (Kompus, Olsson, Larsson, & Nyberg, 2009).

WM is often referred to as an executive function that involves several executive processes that together create an ability to hold in mind and manipulate representations (Baddeley, 2003). Executive functioning further entails processes of attentional monitoring and flexibility, shifting between tasks or mental sets, maintenance and updating of information held in mind/focus, and inhibition of responses. These executive functions are important in managing every-day life, including tasks such as planning and problem solving, and are also important for self-regulation, emotional regulation and coping with stress (Compas, 2006; Kaplan & Berman, 2010; Ochsner, Silvers, & Buhle, 2012). Executive cognitive processes involved in WM and flexibility heavily depend on prefrontal cortical (PFC) brain regions, prefrontal-parietal networks and the hippocampus (Moll, de Oliveira-Souza, Moll, Bramati, & Andreiuolo, 2002; Nee & Jonides, 2011, 2013; Oztekin, Davachi, & McElree, 2010; Oztekin, McElree, Staresina, & Davachi, 2009; Poch & Campo, 2012; Zakzanis, Mraz, & Graham, 2005).

Another type of division of cognitive functions often made is in terms of fluid versus crystallized cognitive abilities. Executive functions and episodic memory are generally classified as indicators of fluid cognitive ability, while semantic memory is classified as an indicator of crystallized ability.

Episodic memory and executive functions, and brain regions that these functions heavily depend on (hippocampal and PFC regions), have been found to be sensitive to both aspects of psychological health like stress, depressive symptoms and sleeping problems, that are common in the work force, as well as the development of dementia (i.e. age related or AD). Semantic memory is generally highly associated with education as well as with fluid cognitive functions like episodic memory and executive functioning. However, semantic memory has been found to be relatively less prone to decline from degenerative processes than these fluid abilities (Kaufman & Horn, 1996; Salthouse, 2010), although declines in semantic
memory is a predictor of AD and may thus be used to distinguish AD from cognitive aging. Due to the relative robustness of semantic memory to decline, it has been used as an indicator of cognitive functioning level prior to (actual or suspected) cognitive decline where assessment of actual cognitive change is not possible (Almkvist, Adveen, Henning, & Tallberg, 2007; Almkvist & Tallberg, 2009). Semantic memory functioning may thus be used as an indicator of whether different levels of SCC may be related to general cognitive ability or to specific cognitive functions that may be more sensitive to detrimental effects from other common psychobiological processes that may impact on cognitive health. For example, if semantic memory, in addition to other cognitive functions, is poor, this may in non-elderly be an indicator of generally low cognitive ability, rather than acquired deficits. On the other hand, if semantic memory is good, while there are deficits in other cognitive domains, this could indicate that decline in the implicated functions have occurred.

SCC

The subjective experience of having problems with cognitive functioning is often referred to as subjective cognitive complaints, although other terms are sometimes used in the literature (e.g. subjective cognitive impairment). SCC can encompass problems with memory, concentration, decision-making, and thinking clearly. Some studies also focus specifically on e.g. subjective memory complaints/impairment or attention complaints. How subjective complaints relate to objective cognitive functioning, which is possible to measure via standardized cognitive tests, is, however, far from clear.

SCC and cognitive functioning among elderly, approximate age ≥65 years

SCC are common among elderly people and may be attributable to cognitive aging processes that are natural or pathological (Geerlings, Jonker, Bouter, Ader, & Schmand, 1999; Jonker, Launer, Hooijer, & Lindeboom, 1996; Lam, Lui, Tam, & Chiu, 2005; Treves, Verchovsky, Klimovitzky, & Korczyn, 2005). The potential connection between SCC and underlying neurological pathology, and the potential utility of SCC as an easy tool for detecting developing dementia have spurred research on the neuropsychological correlates of SCC primarily among elderly people.
Previous research among elderly (approximately ≥65 years) has shown a mixed picture of the relationship between SCC and cognitive functioning. Some studies have demonstrated a zero relationship cross-sectionally (e.g. (Rabbitt & Abson, 1990, 1991; L. M. Reid & Maclullich, 2006). Others have found SCC among elderly people to be related to concurrently measured cognitive functioning level (Genziani et al., 2013; Jorm, Butterworth, et al., 2004), future cognitive impairment (e.g. mild cognitive impairment: MCI), subsequent dementia (especially Alzheimer’s disease: AD) and increased rates of cognitive decline (Hohman, Beason-Held, Lamar, & Resnick, 2011; Jessen et al., 2010; Jonker, Geerlings, & Schmand, 2000; Jonker et al., 1996; Jorm, Christensen, Korten, Jacomb, & Henderson, 2001; Jorm, Masaki, et al., 2004; Reisberg, Shulman, Torossian, Leng, & Zhu, 2010). These latter studies often have stronger designs in terms of longitudinal measurements, sampling from community or general populations, larger sample sizes, and more robust neuropsychological measurements.

**SCC and cognitive functioning among younger adults, approximate age 20-65 years**

Although SCC are common among elderly, a higher prevalence of SCC have sometimes been observed among those of younger age (e.g. (Rabbitt & Abson, 1990).

However, when it comes to non-elderly adults, approximately within the age span of 20-65 years, only a few studies exist on SCC in relation to actual cognitive functioning that have included this age group and the findings vary. For example, Podewils and colleagues (Podewils, McLay, Rebok, & Lyketsos, 2003) found in a general population sample of 1488 participants with a wide age range (31-97) that subjective memory ratings were associated to all four measures of memory functioning used (verbal delayed recall score, discrimination index/recognition test, mini mental status examination [MMSE] score and past change in MMSE score). Ruiz-Sanchez de Leon and colleagues (Ruiz-Sanchez de Leon, Llanero-Luque et al. 2010) also found SCC to be related to poorer functioning on declarative memory and executive tasks in a community based sample. Bolla and colleagues (Bolla, Lindgren, Bonaccorsy, & Bleecker, 1991) found a relationship between SCC and verbal intelligence in a sample of 199 adults (age 39-89 years) and Reid et al. found associations to a range of tests including episodic memory and executive function among 866
aircraft maintenance personnel (ages approximately 29-60) (M. Reid et al., 2012).
Others have not found an association to cognitive function at all in a general population sample (Scholtissen-In de Braek et al., 2011), and in a community sample, except among those that were retarded or demented (Bassett & Folstein, 1993). However, the cognitive measures used were rather limited in one of these studies (Bassett & Folstein, 1993).

Thus, findings from previous studies including non-elderly adults have been rather few and inconclusive, with no studies of gainfully working adults that are population-based.

**SCC and brain function**

When considering what SCC may represent in terms of actual cognitive functioning, it is also worth looking at relationships with underlying brain functioning, as this may provide additional information regarding aspects of neuropsychological function that may not be detected from conventional neuropsychological assessments used in previous studies. Such information may also be worth to consider when interpreting the potential meaning of findings regarding the relation between SCC and cognitive functioning.

SCC among elderly have been found to be related to changes in brain structure/brain degeneration (Jessen et al., 2006; Striepens et al., 2010), altered functional brain activation patterns (Erk et al., 2011; Hohman et al., 2011) and altered metabolism in the brain (Scheef et al., 2012). One of these studies found that atrophy in the functional brain regions of the entorhinal cortex and hippocampus (important for memory formation and retrieval) is present at the stage where SCC are present but cognitive impairments are not detectable by conventional neuropsychological assessments. Furthermore, they found that the magnitude of atrophy seen in these regions was gradually greater in persons where cognitive impairments were detectable (i.e. MCI) and was the greatest in AD conditions (Scheef et al., 2012).

These observations suggest that SCC may be indicators that actual neuropsychological functioning is implicated. In the above studies, the findings seem to suggest that SCC in elderly individuals can be early
indicators of potential underlying etiology of brain degeneration that can precede cognitive functional decline detectable via traditional neuropsychological assessments.

**Potential causes of SCC**

There are a range of factors that could potentially cause SCC, as well as cause deficits in cognitive neuropsychological function.

SCC among elderly may more often be related to underlying dementia pathology or other neurological aging processes, as well as other aspects of psychological health (as mentioned in a previous section). Potential underlying causes of SCC in non-elderly populations, on the other hand, may more often have to do with psychological health and related non-pathological psychobiological processes of allostasis and allostatic load (processes of homeostasis and wear and tear on the body and brain with accumulated stress exposure- see below) that are unfavourable to brain functioning and cognitive functioning, as well as to other aspects of mental and physical health (Juster, McEwen, & Lupien, 2010).

Along this line, non-elderly adults more often report stress and related constructs like tension and emotional problems as causes of their SCC, while elderly more often report aging as the cause (Ponds et al., 1997; Vestergren & Nilsson, 2011).

For individuals in the working population, working conditions constitute a major source of psychosocial exposure, where different types of exposures or stressors can be either supportive of- or detrimental to- health in general as well as to cognitive health through their effects on for example individual stress levels.

In the below subsections, the potential significance of the above mentioned factors will be reviewed. First some common problems with psychological health will be briefly reviewed. Then the mechanisms by which work environment may be supportive or detrimental to cognitive health, which may partly explain SCC among working adults, will be
considered. Further down, work environment, mental health and SCC will be reviewed in a separate section.

Aspects of psychological health

SCC has repeatedly been found to be related to common psychological problems, like symptoms of depression, anxiety, chronic stress or exhaustion and sleeping problems, both among non-elderly general population samples (Lozoya-Delgado, Ruiz-Sanchez de Leon, & Pedrero-Perez, 2012; Scholtissen-In de Braek et al., 2011; Stenfors et al., 2013), and elderly (Jorm, Butterworth, et al., 2004; Jorm et al., 2001). Furthermore, affective symptoms, chronic stress and sleeping problems have all been related to actual objectively measured decrements in cognitive functions such as episodic and executive functions (e.g. (Murrough, Iacoviello, Neumeister, Charney, & Iosifescu, 2011; Åkerstedt, 2007; Öhman, Nordin, Bergdahl, Slunga Birgander, & Stigsdotter Neely, 2007)) .

Some have argued that SCC are better explained by such other psychological health aspects (like depressive and other affective symptoms) than objective cognitive functioning since SCC have been found to be more strongly correlated with psychological symptoms like depression, both in samples of elderly (e.g. (Jorm, Butterworth, et al., 2004; Jorm et al., 2001)) and non-elderly (e.g. (Bolla et al., 1991; M. Reid et al., 2012)).

Thus, these other aspects of psychological health may partly explain the experience of SCC, and may also contribute to objective cognitive problems. Covariance between these psychological symptoms, SCC and objective cognitive functioning measures may also be explained by another set of factors that together constitute an underlying aetiology common to all those symptoms/conditions. In either case, these psychological health aspects are therefore important to consider in the study of the relationships between subjective and objective cognitive functioning.

Similarly, depressive symptoms and sleeping problems have also been related to working conditions (L. Magnusson Hanson et al., 2009; Rau, Morling, & Rosler, 2010; Stansfeld & Candy, 2006; Åkerstedt et al., 2002). Therefore, these symptoms/conditions may also mediate relationships between working conditions and SCC and are of interest to consider in analyses of the relationships between working conditions and
SCC. Again, however, covariance between all these factors may also be explained by another factor, or common underlying aetiology.

**Appraisal**

The link between psychosocial factors and aspects of health has often been explained within a general framework of stress theory (also supported by empirical studies), whereby psychological stress (often equated with distress) arise as the result of an individual’s appraisal of his/her environment/situation as being taxing or exceeding his/her resources to deal with the stressor/s or endangering his/her well-being (Lazarus & Folkman, 1984). That is, the effects that psychosocial factors can have on health may come about via appraisal processes, that in turn activate multiple biological systems (stress responses) in order to deal with the threat. These biological processes are interdependent and affect different aspects of psychological and physical health. Appraisal processes and coordination of stress responses depend on prefrontal cortical (PFC), hippocampal and amygdalae brain regions (McEwen, 2007) and may be both conscious as well as unconscious. Responses to certain stimuli may be conditioned and more or less automatic.

Perceived/appraised psychosocial stress initiates a series of biological and psychological processes that serves to recruit extra resources in order to handle the immediate situation and can be regarded as adaptive. These biological processes have been termed allostasis (Juster et al., 2010).

**Allostasis**

Allostasis refers to “the processes whereby an organism maintains physiological stability by changing parameters of its internal milieu by matching them appropriately to environmental demands” (Juster et al., 2010).

More specifically, when faced with a stressor appraised as a threat the two stress-axes are activated: the sympathetic-adrenal-medullary (SAM) system is activated in a matter of seconds and increases the release of catecholamines like adrenaline, and then the hypothalamic-pituitary adrenal axis (HPA) is activated and results in increased release of glucocorticoids (cortisol in humans).
Together the stress response generally puts the organism into a state of readiness for fight or flight in order to ensure survival from the threat. This includes for example increased heart rate, release of fatty acids and glucose into the blood stream, heightened skeletal muscle contractions, altered immune activity, decreased digestive activity, increased blood coagulation, etc. (Sapolsky, Romero, & Munck, 2000).

Cognitive functioning is also affected by the acute stress response, via activation of the SAM and HPA resulting in increased levels of adrenaline, glucocorticoids (cortisol in humans), and neurotransmitters like glutamate, dopamine and noradrenaline. These transmitter substances are important for alertness and cognitive functions like learning/memory encoding and executive functioning like working memory and attentional control (Arnsten, 2009).

Acute stress and cognition

Several studies have shown that acute (temporary) stress can have deleterious effects on cognitive functioning, especially executive functioning (often WM performance is studied), and related PFC brain regions (Alexander, Hillier, Smith, Tivarus, & Beversdorf, 2007; Arnsten, 2009; Elzinga & Roelofs, 2005; Luethi, Meier, & Sandi, 2008; Oei, Everaerd, Elzinga, van Well, & Bermond, 2006; Qin, Hermans, van Marle, Luo, & Fernandez, 2009; Schoofs, Preuss, & Wolf, 2008; Schoofs, Wolf, & Smeets, 2009).

Both episodic memory function and executive functioning have been observed to have an inverted-U-shaped relation to the levels of glucocorticoids and/or the other mentioned neurotransmitters (Arnsten, 2009; de Kloet, Oitzl, & Joels, 1999; Lupien, Maheu, Tu, Fiocco, & Schramek, 2007). That is, these cognitive functions operate optimally at a certain intermediate level of arousal, and sub-optimally at too low or too high levels of arousal.

However, it seems that executive functioning is particularly sensitive to heightened stress arousal and deteriorates at lower arousal levels than do episodic memory (Luethi et al., 2008; Lupien, Gillin, & Hauger, 1999). For example, moderate psychosocial stress induced by a public speaking task in front of a critical audience is enough to impact working memory
functioning negatively, while episodic memory performance may be enhanced, especially for stressor-related information (Luethi et al., 2008).

Acute stress may have negative impacts on cognitive functioning when stress exceeds a certain level, but such effects are transitory and disappear after recovery from the stress exposure. However, chronic cumulative stress exposure, and allostatic load processes, may lead to more chronic problems with subjective and/or objectively measured cognitive functioning that often persist even after long-term sick-leave (Socialstyrelsen, 2003).

Allostatic load

Allostatic load “represents the ‘wear and tear’ the body experiences when repeated allostatic responses are activated during stressful situations” (Juster et al., 2010) and involves overactivation, underactivation and/or dysregulation of responses by different allostatic systems (McEwen, 2003).

Such allostatic load processes have been related to a range of psychological symptoms, like symptoms of stress or exhaustion, depression, sleeping problems, as well as somatic conditions, e.g. pain, gastro-intestinal problems, and cardiovascular disease.

Chronic stress and cognition

The connection between allostatic load processes, in particular cumulative stress-signalling (most directly measured in animal studies or patients with medically/therapeutically induced hypercortisolemia) or chronic exposure to psychosocial stressors in humans (where allostatic load is often inferred rather than successfully measured), and cognitive and brain function is also well established through studies from different research fields (Juster et al., 2010; McEwen & Gianaros, 2011). The effects of chronic stress on brain and cognition also seem more long lasting and stable across time than the transient effects seen in experimental studies with an acute and moderately stressful situation, as described above. Findings from clinical studies include e.g. reduced cognitive functioning in chronic stress patients (i.e. burnout or exhaustion) (Oosterholt, Van der Linden, Maes, Verbraak, & Kompier, 2012; Sandstrom et al., 2011; Sandström, Rhodin, Lundberg, Olsson, & Nyberg, 2005; Sandström et al.,
2012; Van der Linden, Keijsers, Eling, & Van Schaijk, 2005; Öhman et al., 2007; Österberg, Karlson, Malmberg, & Hansen, 2012). Furthermore, studies on both animals and humans converge in findings of detrimental effects of chronic stress exposure (i.e. cortisol in humans) on hippocampus dependent memory function and structure in terms of increased atrophy and reduced neurogenesis (Marin et al., 2011; McEwen & Gianaros, 2011) as well as altered prefrontal cortical function and structure, such as dendritic retraction (Arnsten, 2009; Liston, McEwen, & Casey, 2009; McEwen & Gianaros, 2011).

Another example of allostatic processes that have also been linked to negative effects on cognitive functioning (different types of memory function) are levels of immunological activities (i.e. circulating levels of pro-inflammatory cytokines) (Juster et al., 2010; Lekander et al., 2011; McAfoose & Baune, 2009).

Thus, when it comes to psychosocial working conditions, these may determine the level and frequency of stress (as well as the regulation of related allostatic processes) elicited in the individual, where some aspects of work constitute resources that reduce stress, support health and buffer against illness, while other factors constitute stressors that are more resource depleting and may act to increase the level and frequency of acute stress responses in the individual and also contribute to chronic stress exposure. As an example, it has been found in experimental settings that cognitively demanding work tasks elicit heightened stress (or sympathetic arousal, measured via electrocardiogram) (Kristiansen et al., 2009).

Thus, an imbalance between demands/stressors and resources in the immediate situation may cause acute stress responses that can affect certain cognitive functions negatively. When this (perceived/appraised) imbalance between demands and resources persists over time, it can create a strain on the individual via allostatic load processes that affect health negatively, and importantly, more chronically affect brain regions like the hippocampus and PFC and their functionality negatively. Important to remember is that some individuals may be more vulnerable to negative effects on cognition than others, as individuals differ in their appraisal of threat and their regulation of stress responses and other biological systems, which may stem from both genetic predispositions as well as
environmental exposures and the combination of those factors (Juster et al., 2010).

The negative impact of chronic stress on the functioning of these brain regions may in turn lead to a vicious circle where the impact of some initial stressor/s can lead to further stress, as these same areas and functions are involved in coping with stress, like problem solving ability and regulation of the stress response at different levels.

Thus, stress-signalling and related allostatic processes may be plausible and potent underlying causes of SCC among individuals in the non-elderly working population (particularly in those that are vulnerable), also affecting similar functional brain areas as those that are commonly affected in the development of dementia, as well as affecting other psychological symptoms that commonly co-occur with SCC. Allostatic load processes may thus also represent a plausible common underlying aetiology of several different aspects of cognitive and psychological health that are common and often co-occur.

**Other factors**

Other plausible causes of SCC in the work force are cognitive overload (van Merrienboer, 2005), cognitive resource depletion (Persson, Welsh, Jonides, & Reuter-Lorenz, 2007), or fatigue, which may in turn be caused by certain working conditions. Such factors may affect cognitive performance momentarily and may also cause more SCC if experienced often. However, if SCC stem from such transient states, decrements in cognitive functioning should not be found in standardized neuropsychological testing if the individual is not still in such a state.

**Work environment, mental health and SCC**

Today’s labour market is dominated by jobs involving more cognitive demands than physical demands. Modern working life has also been described as intensified in certain respects relating to a greater mental work load (Kompier, 2006). For example, increasing globalisation has created increased competition between companies and rapidly changing conditions at the workplace and in the labour market that employers and
employees continuously have to adapt to. The constant, but still recent, development of information and communication technologies (ICT) has provided new possibilities and new ways of working. But the development of ICT has also created new demands on the employed for communication and information management. The borders between work and leisure have become more erased (Kompier 2006), and the organisation and execution of work tasks have become more scattered. From this follows that cognitive functioning has become ever more vital in order to manage work and stay working and cognitive problems could be an important reason for labour-market exit and inability to return to work. Indeed, as mentioned in previous sections, the major causes of sick-leave today are psychological/mental health conditions that often involve SCC. These SCC can be very troublesome and limit work-ability. Unfavourable psychosocial working conditions have been identified as one category of causes of such psychological conditions and may be an important aspect also of SCC specifically.

However, few studies have investigated the relationship between psychosocial working conditions and SCC (or other, objective, cognitive measures) specifically, and no prior studies exist on nationally representative samples of a work force.

Although cognitive stimulation is essential for strengthening and maintaining cognitive function, working conditions that are unfavourable or place intensive mental demands on the individual can potentially instead increase the risk of SCC, in some individuals. The few previous studies that have investigated different aspects of work in relation to cognitive measures have indicated that this can be the case.

One of the leading work environment models is the demand-control-support model (DCS-m: (B. Karasek & Theorell, 1990)), predicting that high quantitative psychological demands, low control (including low decision authority and low skill discretion) and low social support in the job will be unfavourable to health. The combination of demands and resources available to handle those demands (in the form of control and social support) may determine, to some extent, the health and well-being of the individual. The DCS-m and its subcomponents have been extensively studied and found to be predictive of various health outcomes including psychological/mental health and well-being (Häusser, Mojzisch, Niesel, & Schulz-Hardt, 2010; L. Magnusson Hanson et al., 2009; L.
Studies of SCC and psychosocial working conditions among Danish employees have found high quantitative psychological demands to be positively related to SCC (Albertsen, Nielsen, & Borg, 2001; Albertsen, Rugulies, Garde, & Burr, 2010; Hogh & Mikkelsen, 2005). Furthermore, a positive relationship between high skill discretion and SCC was found, suggesting that exceedingly high demands for learning and skill may turn from being beneficial and health promoting into being adverse. The studies of Danish employees also found SCC to be associated with interpersonal conflicts at work, as well as exposure to violence, role conflicts, and lack of role clarity, - recognition, - predictability, - influence, - social support, - meaning at work, and decision authority (Albertsen et al., 2001; Albertsen et al., 2010; Hogh & Mikkelsen, 2005).

When it comes to studies of objective cognitive functioning, a study of civil servants in Whitehall London found that longer exposure to high strain jobs (high demands and low control) was related to future poorer cognitive performance in civil servants in London (Elovainio et al., 2009). However, this relation disappeared when adjusting for employment grade. Another study found job strain to be related to poorer learning outcomes in call centre employees (Holman & Wall, 2002).

Another factor of high relevance to today’s working conditions is information and communication technology (ICT) usage and demands that have been related to psychological health (Arnetz & Wiholm, 1997) and negative effects on the performance of cognitively demanding work tasks (Eppler & Mengis, 2004). Emotional demands have also been shown to potentially affect SCC negatively (Zapf, Seifert, Schmutte, Mertini, & Holz, 2001).

The work factors presented here are by no means exhaustive and there may be other psychosocial aspects of work that can affect SCC positively or negatively. Other important factors in today’s working life, with potential significance for SCC among the employed, may be the extent to which an individual has adequate resources in the form of own qualifications for the job as well as necessary resources in the organisation, to meet the demands at
work. Such factors may be important as reorganisations of work places, as well as changing jobs, have become increasingly common phenomena.

Given the hitherto few studies with some contradictory findings on working conditions and SCC or cognitive function, mostly carried out on specific groups, general conclusions on this subject cannot be drawn. Further studies of the relationships between psychosocial work factors and SCC are needed on samples that are representative of the general work force.

Other factors that can influence the relation between SCC and cognitive functioning

It is possible that relationships between SCC and objective cognitive functioning may be explained by, or may vary between different groups depending on other factors that are related to both SCC and cognitive functioning.

An important factor is age. SCC are common among elderly, but a higher prevalence of SCC have sometimes been observed among younger adults (e.g. (Rabbitt & Abson, 1990)). This may seem counter intuitive since objectively measured cognitive abilities generally decline with ageing. Typically, episodic memory, and particularly free recall of information (Persson et al., 2012; Rönnlund, Nyberg, Backman, & Nilsson, 2005; Spaan, Raaijmakers, & Jonker, 2003), as well as working memory (Rajah & D'Esposito, 2005), decline with aging. Semantic memory on the other hand seems relatively more robust to decline from for aging, while being more affected in AD (e.g. (Spaan et al., 2003)). However, it should be stressed that there are individual differences in cognitive aging profiles (e.g. (Lovden, Bergman, Adolfsson, Lindenberger, & Nilsson, 2005)).

Sex has also been found to be related to cognitive functioning. Generally, a female advantage has been observed in episodic memory (de Frias, Nilsson, & Herlitz, 2006; Maitland, Herlitz, Nyberg, Backman, & Nilsson, 2004; Zelinski, Gilewski, & Schaie, 1993) and verbal ability (Larsson, Lovden, & Nilsson, 2003). Men on the other hand have been observed to perform better on spatial tasks, at the group level (de Frias et al., 2006).
When it comes to SCC, women tend to report more SCC than men. Prevalence rates of SCC are approximately twice as high among women compared to men in the Swedish work force (measured in the Swedish Longitudinal Occupational Survey of Health: SLOSH).

Other important factors related to aspects of subjective and objective cognitive function are educational level, as well as cognitive and social activity levels. These factors are generally positively associated with cognitive functioning and also seem to protect against cognitive decline. The cognitive reserve hypothesis has been suggested to account for such observations (Stern, 2012; Tucker & Stern, 2011). However, these factors may also affect the frame of reference within which the subjective judgements of cognitive functioning are made, which has been suggested previously by others (Rabbitt & Abson, 1990, 1991). That is, greater cognitive demands means that cognitive abilities are continually tested ecologically and decrements in ability are more likely to be discovered. Greater social interaction also gives a reference of others’ cognitive abilities that one’s own cognitive functioning level can be compared with. Social interactions can also provide feedback from others regarding own functioning. In line with this reasoning, the relationship between SCC and objective cognitive functioning has been found to be stronger among elderly participants who are more socially engaged and active than among those participants who are less so (Trouton, Stewart, & Prince, 2006).

Cognitive and social activity levels may change (often decrease) with age (and particularly with retirement), and may also explain why elderly individuals sometimes are found to self-report fewer cognitive lapses, or less SCC, than younger individuals (e.g. (Rabbitt & Abson, 1990, 1991)). This age-related pattern of SCC is also present in the SLOSH database that is utilized in the studies constituting the basis for the present thesis, although only ages below approximately 65 years are included (these data are not presented).

Together these observations suggest that the relationship between subjective and objective cognitive ability may differ depending on age group, with greater relationships between subjective and objective cognitive ability measures among individuals that are still gainfully working. That is, SCC and relationships with objective cognitive functioning may differ depending on work status, as those who are gainfully employed likely have more cognitive demands and social interactions in daily life that provide them with more information about
their cognitive ability levels and give a different frame of reference, compared to those who are retired and not working. Accordingly, a study of employed and not employed 55-64 year olds found SCC to be related to memory functioning only among those who were continuously employed (Rijs, Comijs, van den Kommer, & Deeg, 2012). Considering that such aspects can influence the relation between SCC and cognitive functioning, it seems important to study different groups separately, such as the gainfully working part of the population. Since few population based studies exist, studying SCC in this group, while controlling for other confounding factors, was an aim of this thesis.
General Aims of the Thesis

The general aims of this thesis were to study the relations between SCC and cognitive functioning, and between SCC and psychosocial working conditions, in population-based samples representative of the Swedish work force. Given that episodic declarative memory and executive functioning (including WM) are implicated in stress-related and other psychological health problems that are common in the working population, these cognitive functions were of particular interest to study in relation to SCC in the work force (study I and II).

Specifically, the following research questions were addressed:

1) Are high levels of SCC among gainfully working individuals related to episodic memory function?

2) Are high levels of SCC among gainfully working individuals related to executive cognitive function?

3) Are SCC related to psychosocial working conditions, cross-sectionally and prospectively?

4) To what extent may other common psychological symptoms (depressive symptoms, sleeping problems, chronic stress symptoms) that co-occur with SCC, cognitive function, and working conditions explain the corresponding relationships in questions 1-3?
Methods

The Swedish Longitudinal Occupational Survey of Health (SLOSH)

Participants were recruited from the Swedish Longitudinal Occupational Survey of Health (SLOSH) - a longitudinal study of work environment and health among Swedish employees that is conducted biennially. SLOSH includes all sectors and is approximately representative of the Swedish work force. The first wave of data was collected in 2006 and the second wave in 2008 by inviting participants from the Swedish Work Environment Surveys (SWES: conducted in 2003 and 2005) to answer more detailed self-completion questionnaires. SWES is conducted biennially by Statistics Sweden and is a stratified random sample of the respondents to the Swedish Labour Force Survey aged 16–64 years.

In 2006, respondents to SWES 2003 were invited to participate in SLOSH wave I with 5985 respondents (65% response rate), out of whom 5141 were “gainfully employed”- defined as working at least 30% on average during the past three months. Respondents to both SWES 2003 and SWES 2005 were invited to participate in SLOSH 2008 with a total of 11,441 respondents (61% response rate), out of whom 9,751 (85%) were gainfully employed.

The third wave of SLOSH data were collected in 2010 and those invited to participate were again the respondents from SWES 2003 and 2005. Additionally, respondents to the SWES from 2007 living in Stockholm county or the counties including and surrounding the Gothenburg area were also invited to SLOSH 2010. Those SWES participants were added to the cohort to increase participant numbers in these areas, in order to facilitate in depth studies dependent on laboratory assessments like study I and II.

Comparisons between the original SWES samples and those who responded to SLOSH have shown that women, older subjects (aged 50+)
and married/cohabiting subjects as well as men and women with high education were overrepresented among responders.

**Participant sample study I and II**

The participant sample in study I and II was a sub-sample of SLOSH wave III, including those fulfilling the case or control participant criteria of reporting either “high” or “low” levels of SCC (see more details regarding SCC below), being gainfully employed, and living in Stockholm county or the counties including and surrounding Gothenburg. The controls were matched to the cases on geographical area, age, sex, and educational level.

All 352 identified cases and 941 case-matched controls from SLOSH 2010 were invited. More controls were invited in order to increase the possibility of getting matching controls for each case deciding to participate. Those consenting to participate were given an appointment in Stockholm or Gothenburg for neuropsychological testing and other physiological measures which occurred within approximately 4-16 weeks of responding to the SLOSH 2010 questionnaire.

A total of 233 participants took part in the study, out of which 116 (30 men, 86 women) were cases, and 117 (26 men, 91 women) were controls. Participants with any known possible brain injury, such as prior head trauma, stroke, or chemical poisoning, as well as psychotic illness, or other illness conditions at the time of testing were excluded from the study. Seven individuals were excluded from the study for such reasons.

The sample of eligible participants thus consisted of 112 cases and 114 controls. Cases were 25-67 years and controls were 29-66 years of age. See table 1 in article I for sample characteristics of the case and control groups.

**Participant samples, study III**

Study III utilized two overlapping samples derived from SLOSH- one sample with only cross-sectional data but a greater number of participants, and the other sample with data from two time points but with a smaller number of participants.
The cross-sectional study sample comprised those respondents to SLOSH wave II (2008) who were gainfully employed (n = 9751). The prospective study sample consisted of those who participated in both SLOSH wave I (2006) and wave II (2008) (n = 4690, 78% of all participants in wave I) and were gainfully employed at both occasions (n = 3644; 46.7% men, 53.3% women).

Compared to all participants in SWES 2003 (n = 9214), a higher proportion of the respondents included in the prospective study sample were in the age range 40–59 in 2003, and a higher proportion had university education. However, the gender distribution was virtually the same, as were the mean scores on demand, control, and support proxy measures from SWES 2003. For more details of the prospective study sample, see [60].

Subjective cognitive complaints (SCC), study I-III

SCC in study I-III were measured in the respective SLOSH waves by four questions about difficulties during the past 3 months with concentration, memory, decision-making, and ability to think clearly on a scale of 1-5/‘Never’-‘Always’. The scale was adopted from the Copenhagen Psychosocial Questionnaire (Kristensen, Hannerz, Hogh, & Borg, 2005) originally from The Stress Profile questionnaire (Setterlind & Larsson, 1995).

The mean score of the four items was used as a global measure of SCC in study I-III and for classifying subjects into high versus low levels of SCC in study II-III. The scale has very high internal consistency (Cronbach’s alpha=0.91). Thus, individual SCC items were not used in the main analyses in the three studies. However, the bivariate correlations between SCC items and cognitive test measures are shown in the appendix in table 2, for reference. More details regarding the scale are also shown in table 1 with self-rated measures in the appendix.

In study I and II, a case and a control group was recruited from SLOSH wave III based on their recently reported SCC index score (i.e. the mean score on the four SCC items). The case group consisted in individuals reporting a high level of SCC, defined as a SCC score of ≥3.25, which corresponds to the presence of at least one of the SCC at least ‘often’, on average. The control group consisted in individuals reporting a low level
of SCC, defined as a SCC score of ≤2.0, which corresponds to the presence of SCC ‘seldom’ or ‘never’ on average. This design with extreme-groups was used in order to limit the necessary number of study participants while still allowing the evaluation of whether a high versus a low level of SCC is related to poorer cognitive functioning.

The cut-offs for the case and control groups were based on face validity and on the distribution of SCC in the gainfully working part of the SLOSH population (8943 people). The SCC scores defined as “high” falls into approximately the top decile of the distribution of SCC, while the SCC scores defined as “low” falls into the bottom 50% of the distribution of SCC scores.

In study I and II, the Cognitive failures questionnaire (CFQ) (Broadbent, Cooper, FitzGerald, & Parkes, 1982) was used as an additional measure of SCC in conjunction with the laboratory test occasion.

Cognitive/neuropsychological measures, study I and II

The categorization of the cognitive tests below is made according to the cognitive domain that each test primarily taps. However, few tests are process pure and thus the tests also overlap, more or less, in the cognitive functions they assess.

It was predicted that high levels of SCC would be related to poorer performance in episodic memory and executive functioning tasks, while SCC was expected to not be related to semantic memory performance.

Episodic memory measures, study I

Face Recognition (Nilsson et al., 2004; Nilsson et al., 1997): Participants were presented with 16 colour photographs of faces of 10-year-old children, and given a delayed free choice (yes/no) recognition test. The performance score was the number of hits (i.e. a yes response to a target face- i.e. a face that had been shown at encoding) minus false alarms (a yes response to a non-target face that had not been shown at encoding).
Immediate free recall (IFR) of words, during focused attention (FA) and divided attention (DA) (Nilsson et al., 2004; Nilsson et al., 1997): Memory encoding and recall during DA conditions tap more prefrontal cortical dependent executive cognitive functioning, than during FA conditions.

In this test participants were presented auditorily with four word lists with 12 items in each list that were presented at a rate of 1 word every 2 seconds. Immediately after each word list had been presented, the participants were asked to recall as many of the words from the presented list as possible in any order (i.e. free recall) during 45 seconds. Participants were instructed to say aloud one recalled word for each ticking sound (i.e. each 2 second interval), without paying attention to if they cannot recall a word for each time interval. A concurrent card-sorting task, forcing the division of attention (DA), was given for conditions 2 (at encoding), 3 (at recall) and 4 (both at encoding and recall), while condition 1 was performed without any concurrent card-sorting (i.e. with FA). The card-sorting task consisted in sorting a deck of cards with a square in the centre coloured either red or black into two piles- one “red” and one “black” pile- sorting one card every 2 seconds. A time indicator (giving a small ticking sound every 2 seconds) was used to standardise the rate of presentation and the magnitude of distraction for all of the words at encoding or recall both within and across the four conditions. The order of the four word lists was counterbalanced across participants in each SCC group.

In all four conditions, the performance score was the number of correctly recalled words from the study list.

The performance scores for condition 1-4 were z transformed and a composite score for recall performance during DA conditions was computed by taking the mean score of conditions 2-4 and transforming this into z scores (see table 2).

Delayed free recall of words: In this test the participants were asked to freely recall (i.e. in any order) as many words as possible from the previously studied word lists from the test IFR. Participants had 2 minutes for recall. The delay period between encoding (i.e. completion of the test IFR) and the testing of delayed free recall of words was approximately 5 minutes long, during which another unrelated test without word material was administered. The performance score was the total number of correctly recalled words.
Composite measure: The raw performance scores from the face recognition test and the delayed free recall of words were transformed into z scores and a composite measure of episodic memory was computed by taking the mean from these two z test measures and transforming this into z scores.

Thus, the episodic memory measures that were used in the analyses were a) a composite of episodic memory, based on the test scores in the delayed verbal recall and delayed face recognition tasks, and b) episodic memory performance in IFR, during FA (condition 1) versus during DA (conditions 2-4).

Semantic memory measures, study I

**Vocabulary:** A revised, 30-item multiple-choice synonym test (Dureman, 1960) was used as an index of semantic knowledge. The task involved selecting the synonym of each target word from among five alternatives within 7 minutes. The performance score was the number of correctly identified synonyms.

**Semantic Fluency:** Two fluency tasks were administered in which the participants were instructed to generate aloud as many words as possible in 1 min. The first task was to produce words beginning with the letter A. The second task was to produce professions beginning with the letter B (Nilsson et al., 2004; Nilsson et al., 1997). While fluency tests tap semantic memory functioning, it should be pointed out that (especially letter-) fluency tasks also rely on executive processes and associated prefrontal cortical brain regions (e.g. (Birn et al., 2010)). This has been most evident in patients with severe/manifest prefrontal brain damage becoming severely impaired on fluency tasks. However, in the present study with participants that do not have any known brain damage, the fluency tests were used primarily as measures of semantic memory functioning.

The performance score for each fluency test was the number of correctly generated words.

Composite measure: The performance scores from the three semantic tests were transformed into z scores and a semantic composite measure was computed by taking the mean from the three z test measures and transforming this into z scores.
Executive cognitive functioning measures, study II

WM was measured using two classical WM tasks, a reading span task (Daneman, 1980) and a verbal 2-back task (McElree, 2001) on a computer. Both these tests were adopted from the Betula Study (Nilsson et al., 2004; Nilsson et al., 1997).

Attentional set-shifting was measured using the trail-making test (TMT) A and B (Tombaugh, 2004).

The reading span task used was a modified version of the original test (Daneman, 1980) with recommended modifications (Conway et al., 2005; Engle, Tuholski, Laughlin, & Conway, 1999). This test requires the simultaneous maintenance of to-be-remembered items and processing of other information and measures verbal working memory capacity.

In this test, the participant is shown a set of sentences, each followed by a word to be remembered, on a computer screen. The participant is required to read aloud the sentence on the screen and answer “yes” or “no” aloud and by pressing a Yes or No key, as to whether the sentence is correct or nonsense. Then the participant is required to read the single word aloud that is presented after the sentence and try to remember this word in the correct serial position for immediate recall after all sentences and words in the trial have been presented. Recalled items at the end of each trial are registered by the test administrator.

A trial contains 2, 3, 4 or 5 sentence-word pairs, i.e. there are 4 different levels of WM load, or difficulty, among trials (level 2-5).

The test contains 16 trials in total, 4 trials at each load level, and trials at different load levels are presented in randomized order to avoid the progressive build-up of proactive interference effects at higher load levels. Two trials (at level 2) were given as training to ensure that the participant had understood the task correctly.

The test measures of verbal WM capacity used were (Friedman & Miyake, 2005): 1) Span level. This is estimated by taking the load level at which the subject can perform ¾ of the trials perfectly, i.e. recall all words in at least ¾ of the trials correctly and in the correct serial order. Added to this number is the proportion of words recalled correctly at the next level. 2) The total number of correctly freely recalled words over all trials, regardless of correct recall of serial position order.

The 2-back task taps the WM processes of maintenance and updating.

In this test, single words are shown on a computer screen consecutively and the task is to answer for each word whether it is the same as the word
shown 2 items back by pressing the ”Yes”- or the ”No” key. There were 40 items (consecutive words) in total. Of these, 22.5 % (9/40) items were ”Hit/target items” (i.e. the word shown is similar to the word 2 items back and the correct response is ”Yes”), 22.5 % (9/40) were target stimuli items (i.e. the stimulus word is new and the same as the word that will be shown 2 items forward), 20 % (8/40) were 3-back items (i.e. the stimulus word is the same as that which was shown 3 items back). Another 20 % (8/40) were 3-back stimulus words (i.e. the stimulus word is new and the same as the word that will be shown 3 items forward). Still another 5% (2/40) were 4-back items, and 5% were 4-back stimulus items, and 5 % (2/40) were new words shown only once in the test session. The trials with 3-back and 4-back items serve as lures, as the participant has to distinguish between recognised items in terms of their order in the stream of stimuli and answer “No” for all items that have been seen if they were not seen exactly 2 trials back.

The stimulus/word presentation duration was 2500 ms and the intertrial interval was 2000 ms.

A block of 15 items were given as training in order for the participant to understand the task correctly, using both target items that required a “yes” response, as well as new and lure items that required a “no” response.

As there are multiple measures from the 2-back task that are being used in the literature, several measures were included also in the present study, in order to give a more full account of test performance. The test measures used were the 1) mean response accuracy, 2) mean response time (RT), and 3) “inverse efficiency” (IE) RT, on a) all 40 trials, b) trials with new word stimuli, c) trials with 2-back/target stimuli, and d) trials with 3-back lure stimuli. IE’s were computed by dividing the response time by the accuracy, for each specified category of items respectively (i.e. a-d) (adopted from (Wild-Wall, Falkenstein, & Gajewski, 2011)). By adjusting the response time as a function of the level of accuracy of responses, the inverse efficiency gives a measure of performance efficiency in the 2-back task. Since there are only 2 trials in the test that are 4-back lures, separate measures on those trials are not presented.

Responding on the 2-back target trials and the 3-back lures is more difficult as they require the ability to discriminate an item in a target position from items in other list positions. New items, in contrast, can be rejected on the basis of an overall assessment of familiarity rather than the retrieval of positional information. Assuming that correct rejection of new items depend on the ability to use the low familiarity value, while correct
responding on 2-back target trials and 3-back lures also depend heavily on
the ability to use positional information, it is logical to analyze both these
trial types separately to investigate updating ability specifically (McElree,
2001). That is, the latter types of trials entail additional cognitive demands
on updating of temporal/order information and are generally more
difficult. Thus, we predicted that accuracy will be lower, response times
longer and IE’s longer in 2-back target trials as well as 3-back lures
among participants with a high level of SCC compared to those with a low
level of SCC, while no group differences were expected on the “easy”
trials with new stimuli words.

The trail-making tests (TMT) A and B assess psychomotor speed and
attentional shifting (Tombaugh, 2004). TMT A is a baseline test condition
where the task is to connect, by making pencil lines, 25 encircled numbers
randomly arranged on a page in proper order. Part A gives a baseline
measure of perceptual processing and motor speed. TMT B additionally
has an attentional shifting component where the task is instead to connect
25 encircled numbers and letters in alternating order. Accuracy and
response times are measured. The main test measures are the response
times in each part and the difference/cost incurred by the shifting
component in part B relative to part A (i.e. response time on part B minus
response time on part A).

Psychosocial working conditions, study III

Psychosocial work factors were measured via self-rating questions in the
SLOSH questionnaire and included the following:

Demand, control and support: Quantitative psychological demands
(having to work fast,-intensively, -with too much effort, not having
enough time, and having conflicting demands), skill discretion (skill
requirements and learning new things versus repetitiveness of work tasks),
decision authority (deciding how and what to do in/at work), and social
support are derived from the DCS-m and were measured by five, four,
two, and six items (scale 1-4) respectively, from the Swedish version of
the Job-Content Questionnaire (B. Karasek & Theorell, 1990; R. Karasek
et al., 1998).

ICT demands were measured by six items (scale 1-5; constructed by H.
Westerlund and M. Baltzer, 2006 (unpublished), largely based on work by
Johansson-Hidén et al. (2003)). Questions concern the extent of
interruptions by- and demands of- having to answer too many e-mails and telephone calls, technical problems with ICT, and erased boundaries between work and leisure.

**Emotional demands** were measured by two questions about frequency of the demand to be empathic/ put yourself in the place of others at work and if work puts you in emotionally disturbing situations (scale 1-4) (Kristensen et al., 2005; Oxenstierna G., 2008).

**Material resources** at work were measured by three questions about resources related to economics, personnel, and equipment (scale 1-4) at wave II. Material resources were measured by a single item at wave I (scale No/Yes).

**Qualification level:** The perceived level of qualification for the job the participant holds was measured by a single item with 5 nominal response alternatives that were recoded into 3 categories: underqualified, qualified, and overqualified.

**Conflicts:** Involvement in any conflict at work in the past two years with superiors, colleagues, or clients was measured by a yes/no question. Current ongoing involvement in any conflict was also measured by a single item (yes/no). These items were combined into three categories: no conflicts, terminated conflicts, and ongoing conflicts.

For more details regarding the scales, see the table of self-rated measures in the appendix.

**Potential confounders included, study I-III**

**Demographic factors**

SCC and/or cognitive functioning are also related (sometimes in different and counterintuitive directions, as mentioned in the background sections) to age, sex and education. As the three studies sought to investigate the role of cognitive and work characteristics in SCC among the employed regardless of these demographic factors, these were also controlled for statistically in all three studies.

Furthermore, the case and control groups tested in study I and II were matched on those variables, as well as on geographical area (as this may affect the variables of interest in unpredictable ways).
Other aspects of psychological health

Depressive symptoms, emotional exhaustion and sleeping problems were measured by self-rating scales in the SLOSH questionnaire (in wave I-III) as follows. See more details regarding the scales in the appendix.

**Depressive symptoms** were measured by six items (scale 1-5) selected from the Hopkins Symptom Checklist depression subscale (SCL-90, (Lipmann, 1986)), which asks about symptoms during the past week. A mean score of 3.83 or higher (range 1-5) has been found to be indicative of major depression (sensitivity 0.68, specificity 0.98) and predict subsequent purchases of antidepressants as well as hospitalisations with a depressive episode (L. L. Magnusson Hanson et al., 2013). Mean scores were used.

**Chronic stress symptoms** were measured by the Maslach Burnout Inventory General Survey, using the subscale of emotional exhaustion measured by 5 items on a scale of 1-6/'A few times a year or less’-‘Every day’. The subscale has proved to be ”the most robust and reliable subscale and also displays the strongest convergent validity but [is] at the same time the least specific dimension of burnout” (Schaufeli & Enzmann, 1998; Vingård E et al., 2001). Mean scores were used.

**Sleeping problems:** The established and validated measures Disturbed sleep index (DSI) reflecting lack of sleep continuity and the Awakening index (AI) reflecting feelings of being insufficiently restored during the past 3 months, were used. Dichotomised variables were used indicating the presence or absence of sleep disturbances and awakening problems, based on four and three items respectively (Kecklund & Åkerstedt, 1992; Åkerstedt, Ingre, Broman, & Kecklund, 2008; Åkerstedt et al., 2002).

Some additional self-rating measures of psychological health were used in conjunction with the test occasion in **study I and II**. These were the following:

**Major depression inventory** (MDI), measuring the degree of depressive symptoms during the past two weeks with 10 items rated on a scale of 0-5 (Olsen, Jensen, Noerholm, Martiny, & Bech, 2003). The sum of item scores (0-50) indicate the degree of symptoms as none (0-23), mild (20-24), moderate (25-29), or severe (≥30) depression.
Shirom Melamed Burnout Questionnaire (SMBQ): a 22 item measure rated on a scale of 1-7. The mean scores were used as indicators of the degree of chronic stress and burnout symptoms experienced during the past month (Grossi et al., 2005; Toker, Shirom, Shapira, Berliner, & Melamed, 2005).
Overview of Studies

Study I


Aim
The primary aim of study II was to test the relationship between SCC and declarative memory functioning. A further aim was to test the potential role of chronic stress, depressive symptoms and sleeping problems in relationships between SCC and declarative memory functioning.

Method
Participants
A total of 233 gainfully employed participants from SLOSH wave III took part in the study and the final sample of eligible participants consisted of 112 cases and 114 case-matched controls. Cases were 25-67 years and controls were 29-66 years of age. See table 1 in article I for sample characteristics of the case and control groups.

Measurements
Measures included were self-rated SCC, scores on cognitive tests of episodic and semantic declarative memory, demographic factors and symptoms of chronic stress, depression and sleeping problems.

The cognitive tests of episodic memory included face recognition, immediate free recall of words during conditions of focused attention and divided attention, and delayed recall of words. The semantic memory tests included a vocabulary test, letter fluency and category fluency.
Analyses
A set of ANCOVA tests were performed to evaluate any group differences between cases and controls in declarative memory functioning.

Results
Significantly poorer episodic memory performance during high executive demands and a trend towards poorer episodic memory was found in the group with high SCC compared to controls with little SCC, while no group differences were found in semantic memory. Furthermore, depressive symptoms, chronic stress/burnout symptoms and sleeping problems were found to play a role in the relation between SCC and episodic memory during divided attention. That is, controlling for these factors reduced the difference in memory performance between the groups with high versus low SCC.

Study II
Stenfors, C., Marklund, P., Magnusson Hanson, L.L., Theorell, T., & Nilsson, L-G. Subjective Cognitive Complaints in the Working Population- The Role of Executive Cognitive Functioning. Accepted for publication in PLoS ONE.

Aim
The primary aim of study II was to test the relationship between SCC and executive cognitive functioning. A further aim was to test the potential role of chronic stress, depressive symptoms and sleeping problems in relationships between SCC and declarative memory functioning.

Method
Participants
See participants in study I.

Measurements
Measures included were self-rated SCC, scores on cognitive tests of executive functioning, demographic factors and symptoms of chronic stress, depression and sleeping problems.
The cognitive tests of executive functioning included the reading span task, 2-back task and trail-making test part A and B.

**Analyses**
A set of ANCOVA tests were performed to evaluate any group differences between cases and controls in executive cognitive functioning.

**Results**
A high level of SCC was associated with significantly poorer executive cognitive performance on all three executive cognitive tests used, compared to controls with little SCC. Additionally, symptoms of depression and chronic stress/burnout were found to play a role in the relations between SCC and executive cognitive functioning, whereby these factors reduced the difference in executive functioning between the groups with high versus low SCC.

**Study III**

**Aim**
The aim of study III was to investigate cross-sectional and prospective relations between psychosocial work factors and reported SCC in The Swedish Longitudinal Occupational Survey of Health- a large cohort that is approximately nationally representative of the Swedish work force, entailing all sectors and occupations.

**Method**
**Participants**
The cross sectional study sample consisted of those respondents to SLOSH wave II (2008) who were gainfully employed (n = 9751).
The prospective study sample consisted of those who participated in both SLOSH wave I (2006) and wave II (2008) and were gainfully employed at both occasions (n = 3644; 46.7% men, 53.3% women).

**Measurements**
Study measures included SCC, psychosocial work factors and other psychological symptoms. The psychosocial work factors studied were: Quantitative psychological demands, decision authority and skill discretion (the control dimension), and social support from the DCS-m, as well as ICT demands, emotional demands, material resources at work, qualification for the job, and interpersonal conflicts at work. Psychological symptoms were depressive symptoms and sleeping problems.
For details regarding self-rating questions and properties of the scales see table A1 in the appendix.

**Analyses**
For both cross sectional data and prospective data, sequential multiple regression analyses were performed with SCC as the dependent variable or outcome, and psychosocial work factors as independent variables or “predictors”.
Subjects with incomplete data on any of the variables of interest were excluded. The resulting cross-sectional study sample consisted of 8362 participants and the prospective study sample consisted of 3264 individuals. Thus, 10.4% were missing from the prospective study sample in the regression models due to missing data.

**Results**
**Cross-sectional results**
High quantitative demands, information and communication technology (ICT) demands, underqualification and conflicts were positively associated with cognitive complaints, while social support, good resources at work and overqualification were negatively associated with cognitive complaints in all models. Skill discretion and decision authority were weakly associated with cognitive complaints. Conflicts were more strongly associated with cognitive complaints in women than in men, after adjustment for general confounders.
Prospective results
Quantitative job demands, ICT demands and underqualification were positively associated with future cognitive complaints in all models, including when adjusted for baseline cognitive complaints. Decision authority was weakly positively associated with future cognitive complaints, only after adjustment for depressive- and sleeping problems respectively. Social support was negatively associated with future cognitive complaints after adjustment for general confounders and baseline cognitive complaints. Skill discretion and resources were negatively associated with future cognitive complaints after adjustment for general confounders. The associations between quantitative demands and future cognitive complaints were stronger in women.
Discussion

Summary

The current thesis investigated relations between SCC and cognitive functioning, as well as psychosocial work environment among the employed, while holding constant age, sex and level of educational attainment. Furthermore, the potential roles of other common psychological problems (i.e. symptoms of depression, chronic stress and sleeping problems) for the above relations were investigated. The main findings of the three studies can be summarized as follows:

1) High compared to low levels of SCC among the employed were associated with poorer executive functioning. Specifically, those with high SCC had poorer performance on the reading span task and verbal 2-back task, tapping working memory processes, as well as on the Trail Making Test part B, assessing attentional shifting (study II). Furthermore, those with high SCC also performed worse on immediate free recall of words during divided attention conditions, an episodic task with high executive demands (study I).

2) A trend was found towards poorer episodic memory among those with high compared to those with low levels of SCC, where memory assessments included face recognition and delayed recall of words (study I).

3) No difference was found between those with high compared to those with low levels of SCC in semantic memory functioning, assessed by tests of vocabulary, category fluency and letter fluency (study I). This suggests that the groups did not differ in general verbal intellectual ability (or prior cognitive functioning levels, in the event of acquired cognitive deficits).
4) The results from study I and II together suggest that high levels of SCC among the employed are associated with selectively poorer executive functioning, and that this difference seems to not stem from a group difference in general intellectual ability.

5) Other psychological symptoms and conditions that are common in the working population, symptoms of depression and chronic stress in particular, and sleeping problems, may explain the observed relationships between SCC and executive cognitive function (study I and II).

6) SCC among the employed were associated with psychosocial working conditions cross-sectionally and prospectively (two time points, 2 years apart). Specifically, cross-sectionally, high quantitative demands, ICT demands, underqualification and conflicts were positively associated with SCC, while social support, good resources at work and overqualification were negatively associated with SCC. Prospectively, quantitative psychological job demands, ICT demands and underqualification were positively associated with future SCC, including when adjusted for baseline cognitive complaints. These relationships were present, albeit weakened, even after additional adjustments for depressive symptoms (which played the greatest role) and sleeping problems. Thus, depressive symptoms in particular, and sleeping problems, may partly explain the relationships between working conditions and SCC (Study III).

Below some of the results will be discussed in terms of interpretation and relation to the literature. Methodological considerations, future studies and the potentially practical significance of the findings will also be addressed.
SCC and cognitive functioning

Study I and II are the only ones, to the author’s knowledge, that have investigated SCC in relation to objective cognitive functioning in a sample of employees that is approximately representative of the general workforce.

The findings in study I and II are in line with some of the findings of previous studies where SCC among adults were related to poorer executive cognitive functioning and episodic memory among middle-aged employees (M. Reid et al., 2012; Rijs et al., 2012), in a community sample (Ruiz-Sanchez de Leon, Llanero-Luque, Lozoya-Delgado, Fernandez-Blazquez, & Pedrero-Perez, 2010), and in a general population sample where SCC were related to episodic memory (executive functioning not tested) (Podewils et al., 2003).

In study I, however, only a trend was found towards poorer episodic memory among those with high levels of SCC. This could be due to the fact that the participants in study I (and II) were sufficiently healthy to be gainfully working.

Furthermore, in study II a greater effect size was found on the complex WM span task, Reading span, as compared to the WM updating task, 2-back, which could suggest that SCC is more associated with specific WM processes tapped by this task. WM span tasks as well as updating tasks require focused attention, and the maintenance of information in the face of distraction. Both types of tasks seem to share important WM processes of building, maintaining, and updating arbitrary bindings (Oberauer, 2007; Schmiedek, Hildebrandt, Lovden, Lindenberger, & Wilhelm, 2009).

However, the extent to which certain processes are tapped by the two types of tasks may differ. While n-back tasks tap updating processes, complex working memory span measures like the Reading span task tap WM capacity to a greater extent. This capacity has been described as “the critical, executive-attention capability by which memory representations—for action plans, goal states, or environmental stimuli—are maintained in a highly active and easily accessible state” (Kane et al., 2004). That is, the demands on temporary storage is greater in the Reading span task than the 2-back task, as there are generally more representations that need to be maintained in a highly active state simultaneously in each trial (2-5 items compared to only the last 2 items in the 2-back task). Furthermore, the RS
task involves a second processing task that is performed in between presentations of the to-be-remembered items, such that additional attentional resources are needed to process this task and to resist interference of the second task with the to-be-remembered items. RS also requires explicit recall of representation. Thus, the RS task place greater demands on simultaneous short term storage as well as resistance to interference from the distracting task- in addition to demands on continuously updating (building and releasing) bindings, that is also required in the 2-back task.

The stronger relation between SCC and complex WM span may thus suggest that SCC in the working population is more strongly associated with WM capacity.

The poorer executive functioning associated to SCC in the working population may potentially be explained by that these functions appear to be the most sensitive to negative effects from both transient stress exposures, as well as chronic stress. These functions may thus be more likely to be negatively affected among working individuals with SCC. Furthermore, many jobs and work environments today may place particularly high demands on executive cognitive functions. Thus, it is possible that any decrements in this cognitive domain are particularly noticeable among individuals who are gainfully working such that those with poorer executive functioning will be more likely to experience the SCC investigated.

Participants in one of the other studies, in which more clear relations between SCC and episodic memory were found, may have had more severe cognitive problems as they were recruited from a memory clinic which they had contacted concerning their SCC (Ruiz-Sanchez de Leon et al., 2010). Furthermore, the greater sample sizes in Reid et al. (2012) (n=866) and Podewils et al. (2003) (n=1488) may explain why significant relationships between SCC and episodic memory were found in those samples of employees and the general population, respectively, even with small effect sizes.

However, while SCC seem to represent accurate observations of own executive cognitive functioning, as well as episodic memory, the statistical relations between these are generally rather weak, as in study I and II.

Some have not found a relation between SCC and cognitive functioning at all (Bassett & Folstein, 1993; Scholtissen-In de Braek et al., 2011).
So, what may these findings mean in terms of practical significance?

**What is the meaning of SCC among working adults?**

Some have suggested that subjective SCC may represent accurate perceptions of underlying degenerative processes, like dementia pathology in *elderly*. Recently, various neuroimaging studies on elderly participants have found SCC (even without manifest cognitive impairments) to be related to altered neuronal/brain functioning that may be non-pathological or pathological (i.e. progressive Alzheimer’s disease: AD) (see e.g. (Erk et al., 2011; Hohman et al., 2011; Scheef et al., 2012; Stewart, 2012; Striepens et al., 2010)). This suggests that people may be aware of changes in cognitive and brain functioning even when these are not detectable from conventional neuropsychological assessments. This may be the case also in non-elderly adults, but with other processes than dementia pathology that are affecting brain and cognition.

So why may it be that SCC and standardized measures of cognitive function are not more strongly related?

Some aspects of cognitive performance, in addition to age and sex, that can obscure the overt relationship between SCC and objective cognitive performance are cognitive reserve and the ability of individuals to engage in cognitive compensatory activities and strategies that may prevent overt signs of cognitive functional decline, e.g. (Stern, 2002). A high cognitive reserve (e.g. high educational attainment) has been particularly associated with a lack of clinical cognitive functional impairments (such as Mild Cognitive Impairment: MCI) even in the instance of SCC, while SCC is more often associated with manifest cognitive impairments (e.g. MCI) in persons with a lower cognitive reserve (Caracciolo, Gatz, Xu, Pedersen, & Fratiglioni, 2012; Stern, 2002, 2009).

A high level of education and/or cognitive function may affect the relation between SCC and objective cognitive functioning in several ways. That is, high education or cognitive functioning may involve better meta-cognitive skills by which cognitive errors are more readily detected, and may also involve a more cognitively challenging daily life (more advanced job, leisure activities and socialization with people that have a high level of education/cognitive ability, etc.) providing continuous opportunities for “testing” and evaluating own cognitive performance. These aspects may
contribute to SCC even when cognitive functioning is still high relative to norms.

Furthermore, SCC has also been found to be associated with the use of more compensatory strategies such as increased effort, cognitive strategies and use of external aids/tools (Garrett, Grady, & Hasher, 2010). Such strategies may uphold cognitive performance even in cases of underlying deficits. Similar suggestions have been made by others who have found compensatory neural activation patterns during episodic (Erk et al., 2011) and working memory tasks (Sandström et al., 2012) in individuals with SCC (compared to controls) even when no decrements in task performance are found.

Thus, is also possible that those individuals with higher education and/or cognitive ability are better able to regulate cognitive performance so as to compensate for self-perceived cognitive problems through the use of cognitive strategies. This again will work against any strong general relationship (across different types of groups) between SCC and objective cognitive performance, even if SCC, and changes in SCC, may be related to brain or cognitive changes within the individual and within groups that are homogenous on such characteristics.

Hence, further studies of the relation between SCC and cognitive functioning should investigate the role of cognitive reserve and compensatory processes in more detail and longitudinally, with analyses also being done after stratification of the samples by these factors, which requires sufficiently large sample sizes.

It is likely that there are costs to some cognitive compensatory activities, such as greater fatigability and loss of energy that can hamper cognitive endurance, i.e. upholding cognitive performance across longer time spans, and that this is perceived by the individual. This is an aspect of cognitive functioning that is important in every-day life but may not be adequately captured by conventional cognitive/neuropsychological tests.

Drawing on these observations, SCC may, in some individuals, reflect a condition of being able to perform a cognitive task at a normative level such that cognitive functioning would not be classified as impaired (e.g. MCI), but it may require more effort, be more exerting mentally and require more restitution.

There is research showing that compensatory activities can uphold cognitive performance momentarily in people with SCC (Erk et al., 2011;
Stern, 2009), and the literature on cognitive aging is converging on the importance of SCC (even without detectable cognitive impairments) as an early marker of actual underlying functional brain changes (Stewart, 2012). In light of such observations, the present findings of cross-sectional relationships between SCC and cognitive functioning (in the episodic and executive domains) may be more important indicators than the effect sizes suggest that neuropsychological functioning is implicated in working adults reporting SCC.

**Psychosocial working conditions and SCC**

There are also other factors that may affect the experience of SCC in the working population. As found in study III, several aspects of the psychosocial work environment were related to SCC both cross-sectionally and prospectively. The most robust findings were the following:

Cross-sectionally, high quantitative demands, ICT demands, perceived underqualification, and conflicts were positively associated with SCC, while social support, good resources at work and overqualification were negatively associated with SCC, even after adjusting for confounders, depressive symptoms and sleeping problems. Prospectively, high quantitative job demands, ICT demands and perceived underqualification were positively associated with future SCC, even after adjusting for confounders, depressive symptoms, sleeping problems and baseline SCC. These findings suggest that certain aspects of the psychosocial work environment may contribute to the development of SCC among the employed, even independently of previous low mood, sleeping problems and SCC.

**How may psychosocial factors affect SCC, and cognitive functioning?**

Some psychosocial working conditions may contribute to the development of SCC based on the results in study III. There are several possible explanations to the observed relationships prospectively and cross-sectionally (which are stronger in the latter case).

As discussed in the background, there are multiple ways by which certain working conditions may give rise to SCC.
High cognitive demands may result in the perception of poorer cognitive functioning due to cognitive errors from cognitive overload or cognitive resource depletion. Certain psychosocial working conditions may also elicit more acute stress reactions (e.g. (Kristiansen et al., 2009)), with momentary aversive effects on cognition, and executive functioning in particular (Alexander et al., 2007; Arnsten, 2009; Elzinga & Roelofs, 2005; Luethi et al., 2008; Oei et al., 2006; Qin et al., 2009; Schoofs et al., 2008; Schoofs et al., 2009).

Such momentary effects on cognition may possibly explain part of the variance in SCC among employees that is not explained by neuropsychological test performance in the lab.

Unfavorable psychosocial working conditions that persist over time may also constitute a chronic stressor psychologically and physiologically with altered allostatic processes (Juster et al., 2010), which may have aversive effects more chronically (more prolonged negative effects) on brain functioning, cognitive executive functioning and episodic memory (Arnsten, 2009; Juster et al., 2010; Liston et al., 2009; McEwen & Gianaros, 2011). Such chronic effects, on the other hand, may explain part of the relationships seen between SCC and cognitive functioning among working adults, which was also suggested by the fact that self-rated chronic stress/burnout symptoms explained part of the relation between SCC and executive functioning.

The role of allostatic load processes in SCC and cognitive functioning in the working population should be directly investigated in future studies.

As it was found in study I and II that SCC were also related to poorer executive functioning, it is possible that unfavorable working conditions can contribute to reduced executive cognitive function via such mechanisms as described above. However, these relationships were not tested directly in any of the studies and thus any firm conclusions cannot be drawn. Future studies should directly test the relations between psychosocial working conditions and cognitive functioning prospectively. Furthermore, studies I and II did not measure changes in cognitive functioning across time, and if these were related to changes in SCC, but only included measures of cognitive functioning at one time point. Thus, the findings cannot tell if poorer executive functioning among those with high SCC are acquired (for example via unfavorable psychosocial...
exposures and stress related mechanisms) or constitute a prior “vulnerability”. Knowing if changes in SCC and executive cognitive functioning are related among working adults would also have provided better grounds for speculating about the nature of relations between working environment and cognitive functioning.

It is also possible that certain working conditions give rise to more SCC in individuals with lower executive cognitive capacity due to those working conditions placing high demands on executive cognitive functions, with resulting perceptions of poor cognitive functioning. That is, those individuals may be more prone to experience cognitive overload (van Merrienboer, 2005) and cognitive resource depletion (Persson et al., 2007) during work situations with high executive cognitive demands. The fact that the factors high psychological demands, ICT demands and underqualification were the strongest predictors of SCC may support this reasoning, as these work features can be assumed to place high demands on executive cognitive functions. Furthermore, problems with executive cognitive functioning may also affect the perceptions of certain features of the work environment (especially those that tap executive functions) as more demanding, etc., than they would be perceived by someone with better executive cognitive functioning.

However, the relations between psychosocial work environment, SCC and cognitive functioning are most likely complex and multidirectional, where the different processes affect each other. For example, an individual with lower executive cognitive ability may also be more prone to experience certain work features as stressful, which may cause stress reactions that further affects executive functioning negatively. This in turn makes the work tasks seem even greater and more demanding to handle. Aversive psychosocial working conditions may also be the starting point in such a vicious circle by affecting stress levels and executive cognitive functioning negatively, which in turn makes the work aspects that are demanding on executive cognitive resources even more challenging and hard to cope with.

The suggested possible ways in which different factors may interact and affect SCC is illustrated the model below (Figure 1). The red boxes and red lines illustrate possible mediators or relations between the factors in the circles.
Changeability of SCC and cognitive functioning

As several factors in the previous and/or current psychosocial working environment may contribute to SCC (study III), considering and changing psychosocial work factors where needed may be important both in prevention and reduction of SCC among the employed. Decrements in executive cognitive functioning are possibly the kind of cognitive problems that are the most common among people with SCC in the working population, as suggested by the results in study I and II. This may be promising, as SCC and related executive cognitive deficits appear changeable in both negative and positive directions among otherwise healthy adults, depending on e.g. the level of pressure and stress load in the job. That is, executive functioning may become poorer for a longer time or chronically from psychosocial stress (i.e. not only affected for the duration of an acute stressor and stress reaction), but may also recover and return to prior functional levels if psychosocial stress exposure is
decreased for a period of time. This has been shown by Liston et al. (2009) who found that college students who were under high pressure during a period of weeks when they were studying for their exams both experienced more difficulties with cognition and showed reduced executive functioning on behavioural tests and related neural activity (measured with functional magnetic resonance imaging). These effects were reversed after four weeks of low pressure. This indicates that both subjective and objective executive cognitive functioning may be changeable across relatively short periods of time if psychosocial stress exposure is modified.

Generally, stress reduction, may result from e.g. either or a combination of lowered external demands, lowered internal demands, and changed patterns of appraisal of external and/or internal demands that improve resilience to stressors. That is, generally reducing objective work demands is not necessarily the solution. Rather, changing certain factors (e.g. ICT related routines) at work may result in a better cognitive work environment which may instead improve productivity at work. Furthermore, learning across time from experience with demanding work situations (e.g. how to perform a certain job effectively) may also create resilience to those stressors, resulting in less appraisals of “threat”, aversive stress and SCC. The negative relation between SCC and feeling underqualified, and the positive relation between SCC and feeling overqualified, suggest this is the case in study III. However, if the external conditions and/or appraisal patterns do not change in a way that lowers stress, then the subjective as well as objective cognitive problems may instead persist over time. Interventions at several levels may thus successfully prevent and/or reduce SCC and problems with executive cognitive functioning.

Overlap between SCC, executive cognitive function and other aspects of psychological health

Just like others have repeatedly shown, here too, SCC are greatly overlapping with depressive and chronic stress symptoms, as well as sleeping problems. Specifically, in study I, adjusting for depressive symptoms reduced the effect of SCC of memory performance during
diverted attention to non-significance, as did adjustment for emotional exhaustion symptoms, but to a lesser extent. Adjusting for sleeping problems also reduced the effect of SCC, but had the smallest effect. In study II, the relations between SCC and the executive cognitive measures were also reduced primarily after adjustment for depressive symptom or chronic stress, and to a lesser extent by sleeping problems. However, the group with high SCC still had poorer performance on the test of WM capacity, Reading span, even after adjusting for either of these factors, suggesting that none of the factors alone could explain the relation between SCC and WM capacity. This test is also particularly demanding, but without floor effects, where no participant could achieve the maximum score. Thus, any individual differences in WM, and particularly WM capacity, should be more likely to be detected by this complex WM span task. This is also suggested by the fact that the Reading span task generated the greatest effect size in study II. This may also explain why the effect of SCC group on Reading span test performance was more robust to adjustments for other related psychological symptoms. The high overlap between SCC, depressive and chronic stress symptoms was expected, as others have found relationships between these factors. However, the cross-sectional design in study I and II does not allow for inferences to be made regarding causality in the relationships between these symptoms, SCC and executive functioning. There are several possibilities as to how these symptoms are inter-related in the working population. SCC and executive cognitive problems may be part of, and secondary to, depressive and stress-related conditions among employees to a large extent, as executive cognitive functioning is also known to be implicated in these conditions. In this case, SCC may be prevented or treated via prevention and treatment of these conditions. However, the SCC and associated executive dysfunctions may stem from similar underlying processes as those that are also associated with symptoms of depression and chronic stress and that have been shown to be suboptimal for executive cognitive functioning. Such processes involve for example altered activity and regulation of the hypothalamic-pituitary-adrenal axis (with sub- or supra-optimal levels of stress hormones), immunological activity, as well as over-reactive amygdala, reduced functional activation of prefrontal cortical regions during executive tasks (WM), reduced functional connectivity between the prefrontal cortex and amygdala, and smaller hippocampal size.
Future studies should investigate the extent to which such mechanisms may explain SCC and associated poorer executive functioning among working adults. Furthermore, reduced executive functioning can also reduce the capacity to cope with stressors and regulate emotions and thoughts, and may thus make a person more vulnerable to depressive and stress-related symptoms. Consequently, there may be multiple strategies of preventing and treating SCC, at the individual level as well as the organisational and work place level.

When tailoring treatments or interventions for SCC to the individual, the role of other psychological symptoms for the presence of SCC should also be considered. That is, other psychological problems may constitute either causes of the SCC, or, they may be the result of another underlying cause that is common also to the SCC. A combination of these two alternatives is probably likely.

**SCC, work situation and gender**

It is worth noting that almost twice as many women as men in the work force report high levels of SCC, as well as depressive symptoms. Differential working conditions and a higher work load in private life in combination with high job demands may contribute to this pattern in women.

In study III, a gender difference was seen cross-sectionally in that conflicts were more strongly associated with cognitive complaints in women than in men. However, when adjusting for depression, the higher association in women dropped, suggesting that depressive symptoms are more co-occurring with- and possibly a mediator of- cognitive complaints in women when there are conflicts at work. This may also partly be explained by depressive symptoms generally being more prevalent among women than men (Ayuso-Mateos et al., 2001; Försäkringskassan, 2011).

A clear gender interaction was also observed in the prospective results wherein quantitative demands were consistently more strongly associated with future cognitive complaints in women than in men. Only in women were quantitative demands a clear predictor of future cognitive complaints.
even after all adjustments, including adjustment for baseline cognitive complaints.

There are multiple possible reasons for this gender difference. Women having a higher work load in private life (StatisticsSweden, 2010) can play an important role in magnifying the risk for aversive effects from high quantitative job demands (Mellner, Krantz, & Lundberg, 2006), as well as limiting the benefits of other potentially protecting factors like job decision authority. The stronger relation between high demands and cognitive complaints among women could be due both to a higher total work load of paid and unpaid work, as well as role-conflicts concerning work versus private life priorities in day-to-day life (Grönlund, 2007), and should also be considered in future work.

The characteristics of a work situation associated with high job demands could also differ between genders in ways that are important for the actual work load.

For example, qualitative studies on women with high job demands and job-stress related exhaustion have conveyed a pattern that differentiates the situation of these white-collar women in relatively high positions from their male colleagues (Sandmark & Renstig, 2010). In addition to a higher work-load in private life, these women also tend to get a higher load at work from getting and taking on extra (extra-role) tasks that are asked for, as well as even performing others’ tasks, as there is a perception that this is expected and required of them to keep the job (Sandmark & Renstig, 2010). “There is a felt pressure to achieve more because you are a woman, a kind of loneliness and lack of female mentors, and prevailing feelings of not being good enough” (Sandmark & Renstig, 2010).

Similarly to not feeling good enough, self-efficacy has been found to be lower in women than in men. In a controlled laboratory study female managers attributed their successes in task-performance (in the lab) less to own ability than did the male managers (Rosenthal, Guest, & Peccei, 1996). Parallel to such findings of lower self-efficacy in women compared to men, in our study sample women more frequently report perceptions of being underqualified for the job (women 20%, men 15.7%) while men on the other hand more frequently report perceptions of being overqualified for the job (women 23.2%, men 27.7%).

It has also been found that having a high sense of job self-efficacy increases the benefits of high job control, while having a low self-efficacy in the job can make a high level of job control aversive to coping with job
demands and to health outcomes (Schaubroeck, Jones, & Xie, 2001; Schaubroeck & Merritt, 1997).

Considering that women are generally more educated than men, while being fewer at leading job positions (Jacobsson, 2008; OECD, 2007), women should not generally have to perceive themselves as less qualified for their jobs than men.

However, employee self-efficacy has also been shown to be affected by the leadership style and support from superiors in the job (Walumbwa, Avolio, & Zhu, 2008; Walumbwa & Hartnell, 2011; Walumbwa et al., 2011). Furthermore, research findings have also shown the operation of “glass ceilings” (Forster, 1999; Liff & Ward, 2001; G. N. Powell & Butterfield, 1994; L. J. Powell, 1999), “glass walls” (Miller, Kerr, & Reid, 1999), and “sticky floors” (Burke & Vinnicombe, 2005; Reskin & Ross, 1992)- hindrances to career mobility, development and advancement in women compared to men- and “glass elevators” and “glass escalators” (Hultin, 2003; Kvande, 2002; Williams, 1992; Wingfield, 2009)- subtle advantages and different support favouring greater career development and advancement at work for men compared to their female colleagues (Wahl, Holgersson, Höök, & Linghag, 2011), indicating differential patterns of support at work for men and women. Women have also repeatedly been found to be rated as less qualified than male counterparts with the exact same qualifications. See for example a recent study by Moss-Racusin et al. on a science faculty’s ratings of job applications (Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012).

Thus, there may be other differences in the psychosocial work environment of men and women that contribute to differential perceptions between men and women regarding own qualification level for the job. Such differential types of demands, expectations, and support- and reinforcement patterns are likely to also determine the magnitude of the job-related work load, play a role in the impact of demands on health and may partly explain why high job demands is a greater risk factor for cognitive complaints in women. These factors could also contribute to the greater frequency of perceived under-qualification among women and create higher self-demands in women (due to other/higher external demands to attain the same positions and benefits as male counterparts), which naturally will be harder to live up to. Women getting more extra role work tasks, as suggested above, could also be an aspect that makes high job demands in women a greater risk factor for cognitive complaints.
That is, women with high job demands may have more extra role tasks that are expected of them on top of the regular work role tasks, compared to male counterparts with little or no such extra role demands. Further studying the distribution and effects of more qualitatively and quantitatively specific/differential types of gendered job support, demands and expectations from superiors and colleagues, would be useful to further map the psychosocial pathways leading to health problems like cognitive complaints in men and women, respectively (de Jonge, Le Blanc, Peeters, & Noordam, 2008; Grönlund, 2007; StatisticsSweden, 2010).

Methodological considerations

Study I and II are cross-sectional studies and thus it is not possible to evaluate causal directions of the relationships between the different factors. For example, it cannot be evaluated whether or not symptoms of depression or chronic stress precede, and may cause, SCC and/or related deficits in executive cognitive functioning among employees. Furthermore, the cross sectional design does not permit conclusions to be drawn regarding cognitive changes. That is, it is possible that individuals reporting SCC have poorer executive functioning in general and that this poorer ability is not acquired in adulthood from for example suboptimal working conditions and stress signalling that have been suggested as possible underlying causes of SCC and poorer executive cognitive functioning. Longitudinal studies of SCC and cognitive functioning among working adults should be done to further elucidate the nature of the relations between subjective and objective cognitive measures, and changes in those across time, in this group. Also in study III, more properly evaluating causality in the relationships between working conditions and SCC would require three measurement points rather than two. Furthermore, considering that SCC and executive cognitive functioning may vary across rather short time periods, it would be suitable to investigate prospective relationships between work factors and SCC across multiple time intervals that are shorter (unlike the two year interval in study III).

The use of self-rating measures of working conditions means that the obtained data are not for objective working conditions. Subjectivity bias is thus introduced. That is, ratings reflect individual perceptions of the
working conditions, individual interpretations of the self-rating questions, and possibly reporting bias. However, some previous studies have compared self-ratings with other types of more objective measures of the work environment and found correspondence between the two, albeit at varying degrees. Such studies have been done on psychological demands and decision latitude (from the DCS-m) where self-ratings have been compared to ratings of demands by a work group, expert ratings or job exposure matrix (Theorell & Hasselhorn, 2005). This has shown that self-ratings have moderate to weak relationships with other, more objective, measurements of psychological demands. For decision latitude, these relationships were strong.

The use of self-rating measures both of working conditions, as well as SCC and other psychological/mental symptoms may have introduced common method bias whereby the relationships between the factors are inflated in study III. For example, all ratings may be affected by the state of mind at the time of the ratings such that negative affectivity make all ratings more negative than “reality”, while a state of denial could make ratings more positive than “reality”.

The additional adjustment for psychological/mental symptoms in all three studies may have induced over adjustment of the main relationships between cognitive functioning and SCC in study I and II, and between work factors and SCC in study III. This is because these psychological/mental symptoms are greatly overlapping statistically with SCC and with work factors, while they may not be the actual mediators or causes of SCC (study I-III) and cognitive deficits (study I and II).

The gender distribution among participants in study I and II reflect the gender distribution of high levels of SCC in the Swedish working population (i.e. measured in SLOSH) which consist of more women than men. Thus, the results in study I and II may be more representative of women than men.

The self-rating measures used differ in the time frame that the individual is asked to consider. For example, regarding the measures used in Study I-III from the different SLOSH waves, SCC and sleeping problems concern the last three months, depressive symptoms concern the last week and chronic stress/burnout symptoms are rated in terms of frequency from “Every day” to ”A few times per year or less/never”. Furthermore, in study I-II, the neuropsychological assessments were made at a later occasion, after the
responses to those measures in SLOSH. This may complicate the interpretation of the results, and could potentially decrease the associations between SCC and performance on the neuropsychological tests, while increasing associations between all the self-rated measures answered on the same occasion. However, measures of depression and burnout symptoms collected at the time of the neuropsychological testing showed similar levels of symptoms to those previously reported in the SLOSH. This was also the case for a subscale on the Shirom Melamed Burnout Questionnaire concerning self-perceived cognitive problems. Thus, cases and controls recruited on the basis of their reported levels of SCC in the SLOSH still had similar levels of complaints at the time of neuropsychological testing. Items on this subscale resembled the SCC items concerning problems with concentration and thinking clearly, but did not include any question on memory. This subscale was also related to the measures of cognitive functioning in a similar way as the measure of SCC used.

Future studies

Future studies should investigate the relation between changes in SCC and cognitive functioning in the working population, as well as investigate the role of allostatic load processes in SCC and cognitive functioning (executive cognitive functioning in particular). Future studies should also further investigate the role of educational level and other markers of cognitive activity levels, for relationships between SCC and objective measures of cognitive functioning. Studies directly testing the relations between work exposures, SCC and cognitive functioning across time would also further clarify the nature of the relations between those factors.
Appendix

Measures from SLOSH in study I-III

The information on factor structure and reliability is based on analyses of responses by gainfully working participants in SLOSH 2008. Some item scores have been reversed before the statistical analyses, such that high values on any index or single item scale always represent a high degree of the measured construct. Measures of psychosocial work environment are only included in study III.

Table 1. Measures from the SLOSH waves in study I-III.

<table>
<thead>
<tr>
<th>Factor/construct</th>
<th>Cronbach’s alpha</th>
<th>Eigenvalue (factors/ Factor loading (items))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subjective Cognitive Complaints</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explained variance: 78.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response alternatives:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5. Alltid- Aldrig.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Always-Never.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Har du under de senaste 3 månaderna…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you experienced problems during the past 3 months with…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)... haft problem med koncentrationen?</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>... had problems concentrating?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)... haft svårt att fatta beslut?</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>...had difficulties taking decisions?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)... haft minnessvårigheter?</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>... had difficulties with remembering?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)... haft svårt att tänka klart?</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>... found it difficult to think clearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quantitative psychological demands</strong></td>
<td>0.75</td>
<td>2.39</td>
</tr>
<tr>
<td>Explained variance: 47.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skill discretion</td>
<td>Explained variance:</td>
<td>0.59</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>------</td>
</tr>
<tr>
<td>Response alternatives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4. Ja, oftast- Nej, så gott som aldrig</td>
<td>Yes, often- No, almost never</td>
<td></td>
</tr>
<tr>
<td>Får du lära dig nya saker i ditt arbete?</td>
<td>Do you have the possibility of learning new things through your work?</td>
<td>0.69</td>
</tr>
<tr>
<td>Kräver ditt arbete skicklighet?</td>
<td>Does your work demand a high level of skill or expertise?</td>
<td>0.76</td>
</tr>
<tr>
<td>Kräver ditt arbete påhittighet?</td>
<td>Does your work require ingenuity?</td>
<td>0.76</td>
</tr>
<tr>
<td>Innebär ditt arbete att man gör samma sak om och om igen?</td>
<td>Do you have to do the same thing over and over again?</td>
<td>0.50</td>
</tr>
<tr>
<td>ICT demands</td>
<td>Explained variance: 60.54</td>
<td>0.87</td>
</tr>
<tr>
<td>Response alternatives:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4= I mycket hög grad- I liten grad/ inte alls.</td>
<td>To a great extent- To a small extent/not at all.</td>
<td></td>
</tr>
<tr>
<td>5=Använder ej dator, telefon, osv, i jobbet.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do not use computer, telephone etc in the job</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Ny teknik och mera flexibla arbetsförhållanden har förändrat arbetslivet för många människor. Teknik kan vara till stor hjälp, men kan också leda till nya typer av stress. Skatta i vilken mån du är stressad av...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New technology and flexible working conditions have changed the working life to many people. Technology can be a great help, but can also lead to new kinds of stress. Estimate the extent to which you’re stressed by...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) ... krav på att alltid vara tillgänglig i arbetsfrågor under arbetstid? ...demands to always be available on work-related issues both during work hours?</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>b) ... krav på att alltid vara tillgänglig i arbetsfrågor under fritid? ...demands to always be available on work-related issues during leisure time?</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>c) ... krav på att snabbt svara på e-post och telefonsamtal som medför mycket arbete? ... demands to give immediate answers to emails and telephone calls that require a lot of work?</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>d) ... att ständigt bli avbruten av telefon och e-post? ...constantly being interrupted by the telephone and email?</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>e) ... datorer och andra apparater som inte fungerar som de ska? ... computers and other equipment that fail to work properly?</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>Emotional demands</td>
<td>0.78</td>
<td>1.64</td>
</tr>
<tr>
<td>Explained variance: 82.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response alternatives:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4. Ja, oftast- Nej, så gott som aldrig. Yes, often- No, almost never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kräver ditt arbete att du ska leva dig in i andra människors situation? Do you in work, have to enter into other peoples situation?</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Försätter ditt arbete dig i känslomässigt svåra situationer? Does your work put you in emotionally disturbing situations?</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Decision authority</td>
<td>0.73</td>
<td>1.59</td>
</tr>
<tr>
<td>Explained variance: 79.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response alternatives:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Har du frihet att bestämma hur ditt arbete ska utföras?
*Do you have a choice in deciding how you do your work?*

| Yes, often- | No, almost never | 0.89 |

### Har du frihet att bestämma vad som ska utföras i ditt arbete?
*Do you have a choice in deciding what you do at work?*

| Yes, often- | No, almost never | 0.89 |

### Resources
Explained variance: 63.11
Ja, ofta- Nej, så gott som aldrig.
Yes, often- No, almost never

| a) Finns det tillräckligt med personal för att du skall kunna klara av ditt arbete? |
| Are there enough personnel in order for you to do your job properly? |

| Yes, often- | No, almost never | 0.77 |

| b) Finns det tillräckligt med ekonomiska resurser för att du skall kunna klara av ditt arbete? |
| Are there enough economic resources in order for you to do your job properly? |

| Yes, often- | No, almost never | 0.84 |

| c) Finns de t tillräckligt med utrustning för att du skall kunna klara av ditt arbete? |
| Is there enough material equipment in order for you to do your job properly? |

| Yes, often- | No, almost never | 0.77 |

### Qualification for the job
Variable coding:

| 1-2= Overqualified |
| 3= Qualified |
| 4-5= Underqualified |

| Hur tycker du att dina kunskaper och färdigheter stämmer överens med ditt arbete? Tycker du att du … |
| Comparing your skills and knowledge with the job you do, do you think you are… |
| Response alternatives: |
| 1... är mycket överkvalificerad? |
| very overqualified |
| 2... är överkvalificerad i vissa avseenden? |
| overqualified in certain areas |

| Yes, often- | No, almost never |

| 74 |
3... är lagom kvalificerad?
*appropriately qualified*

4... skulle behöva ytterligare vissa kunskaper?
*in need of some more skills/knowledge*

5... skulle behöva en hel del ytterligare kunskaper?
*in need of a lot more skills/knowledge*

<table>
<thead>
<tr>
<th>Social support</th>
<th>Explained variance: 58.47</th>
<th>0.86</th>
<th>3.51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response alternatives:</td>
<td>1-4. Stämmer helt och hållet- Stämmer inte alls.</td>
<td><em>Totally correct- Not correct at all</em></td>
<td></td>
</tr>
<tr>
<td>d) Det är en lugn och behaglig stämning på min arbetsplats.</td>
<td><em>There is a calm and pleasant atmosphere where I work</em></td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>e) Det är god sammanhållning</td>
<td><em>There is a good spirit of unity</em></td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>f) Mina arbetskamrater ställer upp för mig</td>
<td><em>My colleagues are there for me</em></td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>g) Man har förståelse för att jag kan ha en dålig dag.</td>
<td><em>People understand that I can have a bad day</em></td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>h) Jag kommer bra överens med mina överordnade.</td>
<td><em>I get on well with my superiors</em></td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>i) Jag trivs med mina arbetskamrater</td>
<td><em>I get on well with my colleagues</em></td>
<td>0.79</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conflicts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Response alternatives:</td>
<td></td>
</tr>
<tr>
<td>Ja/Nej</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Dummy variable coding based on the questions:</td>
<td></td>
</tr>
<tr>
<td>1=There have been conflicts that are either still ongoing or have seized.</td>
<td></td>
</tr>
<tr>
<td>1=There have been no conflicts</td>
<td></td>
</tr>
<tr>
<td>Har du under de två senaste åren varit indragen i någon form av konflikt på din arbetsplats med…</td>
<td></td>
</tr>
<tr>
<td><em>In the past 2 years, have you been involved in any kind of conflict at</em></td>
<td></td>
</tr>
</tbody>
</table>
your workplace regarding...

| a)… chefer?  
...bosses? |
| b)… arbetskamrater?  
...colleagues |
| c)… andra personer (t ex patienter, kunder, klienter, passagerare, elever)?  
... other people (e.g. patients, customers, clients, passengers, students)? |

Pågår någon konflikt fortfarande?

Is there still any conflict at the moment?

Response alternatives:
Ja/Nej.
Yes/No

**Depressive symptoms**

Explained variance: 69.80

Response alternatives:
1-5. Inte alls-Väldigt mycket.
Not at all- Very much

Hur mycket har du den senaste veckan besvärats av…

How much during the last week have you been troubled by:

| a) Tröghet eller brist på energi?  
Lethargy or low in energy? |
| b) Nedstämdhet?  
Feeling blue? |
| c) Att klandra dig själv för saker och ting?  
Blaming yourself? |
| d) Alltför mycket oro för saker och ting?  
Worrying too much? |
<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>e) Brist på intresse för saker och ting?</td>
<td>0.83</td>
</tr>
<tr>
<td>Feeling no interests in things?</td>
<td></td>
</tr>
<tr>
<td>f) Att allt känns ansträngande?</td>
<td>0.87</td>
</tr>
<tr>
<td>Everything is an effort?</td>
<td></td>
</tr>
<tr>
<td><strong>Chronic stress/ Burnout (subscale emotional exhaustion)</strong></td>
<td></td>
</tr>
<tr>
<td>Response alternatives:</td>
<td></td>
</tr>
<tr>
<td>1-6. Varje dag- Några gånger per år eller mindre/aldrig.</td>
<td></td>
</tr>
<tr>
<td>Every day- A few times per year or less/never</td>
<td></td>
</tr>
<tr>
<td>Ange hur ofta du har känt på dessa sätt i samband med ditt arbete?</td>
<td></td>
</tr>
<tr>
<td>How often have you felt this way in relation to work?</td>
<td></td>
</tr>
<tr>
<td>Jag känner mig känslosmässigt tömd av mitt arbete.</td>
<td></td>
</tr>
<tr>
<td>My job makes me feel emotionally drained</td>
<td></td>
</tr>
<tr>
<td>Jag känner mig helt slut när arbetsdagen är över.</td>
<td></td>
</tr>
<tr>
<td>I feel completely worn out at the end of the working day</td>
<td></td>
</tr>
<tr>
<td>Jag känner mig trött när jag går upp på morgonen för att möta en ny</td>
<td></td>
</tr>
<tr>
<td>arbetsdag.</td>
<td></td>
</tr>
<tr>
<td>I feel tired when I get up in the morning to go to work</td>
<td></td>
</tr>
<tr>
<td>Att arbeta under en hel dag är verkligen påfrestande för mig.</td>
<td></td>
</tr>
<tr>
<td>A full day at work is really taxing for me</td>
<td></td>
</tr>
<tr>
<td>Jag känner mig utbränd av mitt arbete.</td>
<td></td>
</tr>
<tr>
<td>I feel burned out by work</td>
<td></td>
</tr>
<tr>
<td><strong>Disturbed sleep index</strong></td>
<td></td>
</tr>
<tr>
<td>Response alternatives:</td>
<td></td>
</tr>
<tr>
<td>1-6. Aldrig-Alltid/5 gånger eller mer i veckan.</td>
<td></td>
</tr>
<tr>
<td>Never-5 times or more per week</td>
<td></td>
</tr>
<tr>
<td>Recoded into dummy variable: presence/absence of disturbed sleep.</td>
<td></td>
</tr>
<tr>
<td>Har du haft känning av följande besvär under de tre senaste månaderna?</td>
<td></td>
</tr>
</tbody>
</table>
### How often have you been troubled by the following in the last three months?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>79. a)</strong> Svårigheter att somna</td>
<td><strong>Difficulties falling asleep?</strong></td>
</tr>
<tr>
<td><strong>c)</strong> Upprepade uppvaknanden med svårigheter att somna om</td>
<td><strong>Repeated awakenings with difficulties going back to sleep?</strong></td>
</tr>
<tr>
<td><strong>e)</strong> För tidigt (slutligt) uppvaknande</td>
<td><strong>Premature (final) awakening?</strong></td>
</tr>
<tr>
<td><strong>f)</strong> Störd/orolig sömn</td>
<td><strong>Disturbed/restless sleep?</strong></td>
</tr>
</tbody>
</table>

### Awakening index

Response alternatives:

1-6. Aldrig-Alltid/5 gånger eller mer i veckan.

*Never-5 times or more per week*

Recoded into dummy variable: presence/absence of awakening problems.

### Har du haft känning av följande besvär under de tre senaste månaderna?

*How often have you been troubled by the following in the last three months?*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>79. b)</strong> Svårigheter att vakna</td>
<td><strong>Difficulties waking up?</strong></td>
</tr>
<tr>
<td><strong>d)</strong> Ej utsövd vid uppvaknandet</td>
<td><strong>Not feeling rested at wake-up?</strong></td>
</tr>
<tr>
<td><strong>g)</strong> Känsla av att vara utmattad vid uppvaknandet?</td>
<td><strong>Feeling of exhaustion at the awakening?</strong></td>
</tr>
</tbody>
</table>
Table 2. Correlations between SCC index, SCC items, SMBQ cognitive subscales and test measures

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCC. index</td>
<td>1.00</td>
<td>.907**</td>
<td>.872**</td>
<td>.916**</td>
<td>.939**</td>
<td>.723**</td>
<td>-.11*</td>
<td>-.136*</td>
<td>-.10*</td>
<td>-.217**</td>
<td>-.257**</td>
<td>-.242**</td>
<td>-.10*</td>
<td>-.03*</td>
<td>-.12*</td>
<td>.175**</td>
<td>.179**</td>
<td>.09*</td>
<td>.227**</td>
<td>.273**</td>
<td></td>
</tr>
<tr>
<td>SCC. item Concentration</td>
<td>.907**</td>
<td>1.00</td>
<td>.784**</td>
<td>.808**</td>
<td>.820**</td>
<td>.682**</td>
<td>-.07*</td>
<td>-.137*</td>
<td>-.04*</td>
<td>-.171*</td>
<td>-.224**</td>
<td>-.156**</td>
<td>-.10*</td>
<td>0.00</td>
<td>0.04*</td>
<td>-.11*</td>
<td>.174**</td>
<td>.176**</td>
<td>.07*</td>
<td>.218**</td>
<td>.264**</td>
</tr>
<tr>
<td>SCC. item Decisions</td>
<td>.872**</td>
<td>.784**</td>
<td>1.00</td>
<td>.754**</td>
<td>.785**</td>
<td>.608**</td>
<td>-.141*</td>
<td>-.09*</td>
<td>-.09*</td>
<td>-.194**</td>
<td>-.248**</td>
<td>-.223**</td>
<td>-.12*</td>
<td>-.04*</td>
<td>0.03*</td>
<td>-.152*</td>
<td>.178**</td>
<td>.191**</td>
<td>.05*</td>
<td>.197**</td>
<td>.244**</td>
</tr>
<tr>
<td>SCC. item Memory</td>
<td>.916**</td>
<td>.808**</td>
<td>.764**</td>
<td>1.00</td>
<td>.872**</td>
<td>.696**</td>
<td>-.08*</td>
<td>-.167*</td>
<td>-.11*</td>
<td>-.206**</td>
<td>-.237**</td>
<td>-.205**</td>
<td>-.09*</td>
<td>-.04*</td>
<td>0.02*</td>
<td>-.13*</td>
<td>.135*</td>
<td>.153*</td>
<td>.06*</td>
<td>.161**</td>
<td>.234**</td>
</tr>
<tr>
<td>SCC. item Thinking</td>
<td>.939**</td>
<td>.820**</td>
<td>.789**</td>
<td>.873**</td>
<td>1.00</td>
<td>.680**</td>
<td>-.09*</td>
<td>-.12*</td>
<td>-.10*</td>
<td>-.199*</td>
<td>-.243**</td>
<td>-.241**</td>
<td>-.06*</td>
<td>-.04*</td>
<td>0.01*</td>
<td>-.12*</td>
<td>.143*</td>
<td>.153*</td>
<td>.08*</td>
<td>.209**</td>
<td>.260**</td>
</tr>
<tr>
<td>Cognitive subscale, SMBQ</td>
<td>.723**</td>
<td>.682**</td>
<td>.608**</td>
<td>.586**</td>
<td>.680**</td>
<td>1.00</td>
<td>-.12*</td>
<td>-.07*</td>
<td>-.04*</td>
<td>-.153*</td>
<td>-.196**</td>
<td>-.196**</td>
<td>-.09*</td>
<td>0.12*</td>
<td>.12*</td>
<td>-.07*</td>
<td>.168*</td>
<td>.147*</td>
<td>.03*</td>
<td>.194**</td>
<td>.266**</td>
</tr>
<tr>
<td>Semantic memory, composite</td>
<td>-.11*</td>
<td>-.07*</td>
<td>-.141*</td>
<td>-.08*</td>
<td>-.09*</td>
<td>-.12*</td>
<td>1.00</td>
<td>.150*</td>
<td>.203*</td>
<td>.243**</td>
<td>.251**</td>
<td>.304**</td>
<td>.215**</td>
<td>-.01*</td>
<td>-.13*</td>
<td>.161*</td>
<td>-.10*</td>
<td>-.175*</td>
<td>-.188**</td>
<td>-.295**</td>
<td>-.256**</td>
</tr>
<tr>
<td>Episodic memory, composite</td>
<td>-.136*</td>
<td>-.137*</td>
<td>-.09*</td>
<td>-.167*</td>
<td>-.12*</td>
<td>-.07*</td>
<td>.150*</td>
<td>1.00</td>
<td>.443**</td>
<td>.384**</td>
<td>.244**</td>
<td>.262**</td>
<td>.279**</td>
<td>-.03*</td>
<td>-.168*</td>
<td>.179**</td>
<td>-.147*</td>
<td>-.184*</td>
<td>-.275**</td>
<td>-.251**</td>
<td>-.213**</td>
</tr>
<tr>
<td>IFR, FA</td>
<td>-.01*</td>
<td>-.04*</td>
<td>-.09*</td>
<td>-.11*</td>
<td>-.10*</td>
<td>-.04*</td>
<td>-.203*</td>
<td>1.00</td>
<td>.391**</td>
<td>.314**</td>
<td>.361**</td>
<td>.247**</td>
<td>.07*</td>
<td>-.08*</td>
<td>.183**</td>
<td>-.05*</td>
<td>-.142*</td>
<td>-.176**</td>
<td>-.256**</td>
<td>-.212**</td>
<td></td>
</tr>
<tr>
<td>IFR, DA composite</td>
<td>-.217**</td>
<td>-.171*</td>
<td>-.194*</td>
<td>-.206**</td>
<td>-.199**</td>
<td>-.153*</td>
<td>-.243**</td>
<td>.388**</td>
<td>1.00</td>
<td>.312**</td>
<td>.399**</td>
<td>-.257**</td>
<td>.01*</td>
<td>-.11*</td>
<td>-.174*</td>
<td>-.170*</td>
<td>-.196*</td>
<td>-.209**</td>
<td>-.327**</td>
<td>-.313**</td>
<td></td>
</tr>
<tr>
<td>RS, span score</td>
<td>-.257**</td>
<td>-.224**</td>
<td>-.248**</td>
<td>-.237**</td>
<td>-.243**</td>
<td>-.196**</td>
<td>-.291**</td>
<td>.244**</td>
<td>.314**</td>
<td>1.00</td>
<td>.773**</td>
<td>.317**</td>
<td>.01*</td>
<td>-.157*</td>
<td>.209**</td>
<td>-.171*</td>
<td>-.214**</td>
<td>-.275**</td>
<td>-.406**</td>
<td>-.361**</td>
<td></td>
</tr>
<tr>
<td>RS, Sum FRC</td>
<td>-.242**</td>
<td>-.196**</td>
<td>-.223**</td>
<td>-.205**</td>
<td>-.241**</td>
<td>-.156**</td>
<td>-.304**</td>
<td>.262**</td>
<td>.361**</td>
<td>.396**</td>
<td>.773**</td>
<td>1.00</td>
<td>.346**</td>
<td>.10*</td>
<td>-.160*</td>
<td>-.268**</td>
<td>-.171**</td>
<td>-.248**</td>
<td>-.292**</td>
<td>-.441**</td>
<td>-.365**</td>
</tr>
<tr>
<td>2-Back, accuracy, all trials</td>
<td>-.01*</td>
<td>-.10*</td>
<td>-.12*</td>
<td>-.09*</td>
<td>-.06*</td>
<td>-.09*</td>
<td>.219*</td>
<td>.279**</td>
<td>.247**</td>
<td>.257**</td>
<td>.317**</td>
<td>.348**</td>
<td>1.00</td>
<td>-.194*</td>
<td>-.622**</td>
<td>-.700**</td>
<td>-.492**</td>
<td>-.689**</td>
<td>-.538**</td>
<td>-.550**</td>
<td>-.412**</td>
</tr>
<tr>
<td>2-Back, RT, all trials</td>
<td>.03*</td>
<td>.00*</td>
<td>-.04*</td>
<td>-.03*</td>
<td>-.04*</td>
<td>.12*</td>
<td>.03*</td>
<td>.07*</td>
<td>.01*</td>
<td>.01*</td>
<td>.01</td>
<td>-.134**</td>
<td>1.00</td>
<td>.871**</td>
<td>-.135*</td>
<td>.544**</td>
<td>.464**</td>
<td>.165*</td>
<td>.09*</td>
<td>.03*</td>
<td></td>
</tr>
<tr>
<td>2-Back, IE, all trials</td>
<td>.03*</td>
<td>.04*</td>
<td>.03*</td>
<td>.22*</td>
<td>.01*</td>
<td>.12*</td>
<td>-.13*</td>
<td>-.168*</td>
<td>-.08*</td>
<td>-.01</td>
<td>-.157*</td>
<td>-.160*</td>
<td>-.622**</td>
<td>-.671**</td>
<td>1.00</td>
<td>-.486**</td>
<td>.744**</td>
<td>.704**</td>
<td>.335**</td>
<td>.332**</td>
<td>.216**</td>
</tr>
<tr>
<td>2-Back, accuracy, hts/2-back</td>
<td>.012</td>
<td>-.11*</td>
<td>-.152*</td>
<td>-.13*</td>
<td>-.12*</td>
<td>-.07*</td>
<td>.161*</td>
<td>.179**</td>
<td>.188**</td>
<td>.174**</td>
<td>.208*</td>
<td>.268**</td>
<td>.700**</td>
<td>-.135*</td>
<td>.448**</td>
<td>1.00</td>
<td>-.450**</td>
<td>-.820**</td>
<td>-.297**</td>
<td>-.387**</td>
<td>-.284**</td>
</tr>
<tr>
<td>trials</td>
<td>.175**</td>
<td>.174**</td>
<td>.178**</td>
<td>.199**</td>
<td>.143**</td>
<td>.168*</td>
<td>-.01*</td>
<td>-.147*</td>
<td>-.05*</td>
<td>-.170*</td>
<td>-.171*</td>
<td>-.483**</td>
<td>.644**</td>
<td>.744**</td>
<td>.450**</td>
<td>1.00</td>
<td>.950**</td>
<td>.303**</td>
<td>.334**</td>
<td>.214**</td>
<td></td>
</tr>
<tr>
<td>2-Back, IE, hts/2-back trials</td>
<td>.175**</td>
<td>.170**</td>
<td>.191**</td>
<td>.153**</td>
<td>.163**</td>
<td>.147**</td>
<td>-.175**</td>
<td>-.184**</td>
<td>-.142*</td>
<td>-.196**</td>
<td>-.214**</td>
<td>-.246**</td>
<td>-.686**</td>
<td>.464**</td>
<td>.704**</td>
<td>.820**</td>
<td>.185**</td>
<td>1.00</td>
<td>.352**</td>
<td>.426**</td>
<td>.306**</td>
</tr>
<tr>
<td>TMT A</td>
<td>.06*</td>
<td>.07*</td>
<td>.05*</td>
<td>.26*</td>
<td>.08*</td>
<td>.03*</td>
<td>-.188*</td>
<td>-.275**</td>
<td>-.179**</td>
<td>-.209**</td>
<td>-.275**</td>
<td>-.252**</td>
<td>-.384**</td>
<td>-.165*</td>
<td>.335**</td>
<td>.257**</td>
<td>.323**</td>
<td>.352**</td>
<td>1.00</td>
<td>.566**</td>
<td>.195**</td>
</tr>
<tr>
<td>TMT B</td>
<td>.227**</td>
<td>.218**</td>
<td>.197**</td>
<td>.131*</td>
<td>.208**</td>
<td>.194**</td>
<td>-.295**</td>
<td>-.281**</td>
<td>-.256**</td>
<td>-.327**</td>
<td>-.436**</td>
<td>-.441**</td>
<td>-.534**</td>
<td>.09*</td>
<td>.332*</td>
<td>-.297**</td>
<td>.334**</td>
<td>.426**</td>
<td>.596**</td>
<td>1.00</td>
<td>.877**</td>
</tr>
<tr>
<td>TMT A-B</td>
<td>.273**</td>
<td>.264**</td>
<td>.244**</td>
<td>.234**</td>
<td>.260**</td>
<td>.265**</td>
<td>-.256**</td>
<td>-.213**</td>
<td>-.212*</td>
<td>-.313*</td>
<td>-.331**</td>
<td>-.385**</td>
<td>-.412**</td>
<td>.03*</td>
<td>.215**</td>
<td>-.254**</td>
<td>-.214**</td>
<td>-.306**</td>
<td>.195**</td>
<td>.817**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

** p < 0.05, * p < 0.01 (2-tailed).
RS = reading span, IFR = immediate free recall, FA = focused attention, DA = divided attention.


Kaufman, A. S., & Horn, J. L. (1996). Age changes on tests of fluid and crystallized ability for women and men on the Kaufman Adolescent and Adult Intelligence
Test (KAIT) at ages 17-94 years. Arch Clin Neuropsychol, 11(2), 97-121. doi: 0887-6177(95)00003-8 [pii]


84


