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Direktor: Univ.-Prof. Dr. Peter Angerer

Psychosocial determinants of work ability and healthy ageing at work

Dissertation

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Jeannette Weber

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Erstgutachter: Prof. Dr. med. Peter Angerer
Zweitgutachterin: Prof. Dr. med. Dr. PH Andrea Icks

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Zusammenfassung

Aufgrund des demografischen Wandels steigt der Anteil und Bedarf von Beschäftigten im höheren Lebensalter. Daher beschäftigt sich diese Dissertation mit der Frage nach persönlichen und arbeitsplatzbezogenen psychosozialen Determinanten erfolgreicher Erwerbsteilhabe älterer Beschäftigter. Dieser Frage wird mithilfe unterschiedlicher methodischer Vorgehensweisen im Rahmen einer kumulativen Dissertation nachgegangen. Zum einen werden mit Hilfe einer Querschnittsanalyse die Zusammenhänge zwischen Telomerlänge als biologischer Altersmarker und Lernmöglichkeiten bei der Arbeit sowie Selektion, Optimierung und Kompensation (SOK) als ressourcenorientierte Handlungsstrategien in einer Stichprobe von Beschäftigten in der Altenpflege untersucht. Im Rahmen einer Longitudinalanalyse werden die Zusammenhänge von subjektiver Arbeitsfähigkeit mit SOK und psychosozialen Arbeitsbedingungen bei einer repräsentativen, bevölkerungsbezogenen Kohorte von älteren Beschäftigten analysiert. Mit Hilfe eines systematischen Reviews wird die bisherige Literatur zu Konsequenzen von Altersstereotypen auf ältere Beschäftigte zusammengefasst. Bei diesen Untersuchungen zeigt sich, dass vor allem vorteilhafte psychosoziale Arbeitsbedingungen mit einer besseren subjektiven Arbeitsfähigkeit assoziiert sind. Ein direkter Zusammenhang zwischen Lernmöglichkeiten und Telomerlänge ist nur schwach ausgeprägt. Des Weiteren sind nur schwache Zusammenhänge von SOK zu Telomerlänge als auch zu subjektiver Arbeitsfähigkeit zu erkennen. Negative Stereotype gegenüber älteren Beschäftigten sind negativ mit Arbeitsengagement, Lern- und Entwicklungsmöglichkeiten und Selbstwirksamkeit sowie positiv mit Renteneintrittsabsichten assoziiert. Die Ergebnisse deuten auf einen besonderen Stellenwert der hier untersuchten persönlichen und arbeitsplatzbezogenen psychosozialen Faktoren auf die Arbeitsfähigkeit von älteren Beschäftigten und gesundes Altern am Arbeitsplatz hin. Aufgrund der Ergebnisse scheint es daher ratsam, Interventionen zur Verbesserung psychosozialer Arbeitsbedingungen als auch zur Reduktion negativer Stereotype gegenüber älteren Beschäftigten zu entwickeln und zu implementieren, um eine erfolgreiche Erwerbsteilhabe älterer Arbeitnehmer zu fördern.

Summary

The current demographic change is accompanied by an increased share and need of older employees. Against this background, this dissertation deals with the topic of personal and work-related psychosocial determinants of work ability and healthy ageing at work. To investigate this topic different methodological approaches are applied within the scope of a cumulative dissertation. First, the relationship between learning opportunities at work, selection, optimization and compensation (SOC) and telomere length among employees in geriatric care are investigated in a cross-sectional study. Telomere length functions as a marker for biological age and SOC comprises life management strategies for successful ageing. Second, relationships of SOC and psychosocial working conditions with subjective work ability are analysed by a longitudinal study within a population-based representative cohort of older employees in Germany. Third, a systematic review is conducted to summarise previous literature on the impact of age stereotypes on older employees. Within those analyses, favourable working conditions were associated with better subjective work ability among older employees. A direct relationship between learning opportunities at work and telomere length was less pronounced. Moreover, only weak associations between SOC and telomere length as well as between SOC and subjective work ability were found. Negative stereotypes towards older workers were negatively associated with work engagement, learn and development intentions and self-efficacy and positively associated with retirement intentions. The results suggest that the personal and work-related psychosocial factors under investigation are important for work ability of older employees and healthy ageing at work. It therefore seems advisable to investigate those relationships further and to eventually develop and implement interventions for the improvement of psychosocial working conditions as well as reduction of negative stereotypes towards older workers to promote the work ability of older employees.

List of abbreviations

CA Cronbach's alpha

COR Conservation of Resources

DNA Deoxyribonucleic acid

EU European Union

JDC Job Demand-Control (model)

JDCS Job Demand-Control-Support (model)

JDR Job Demand-Resources (model)

kb Kilobase pairs

lidA Leben in der Arbeit - living at work

LTL Leucocyte telomere length

q-PCR quantitative polymerase chain reaction

RNA Ribonucleic acid

SOC Selection, optimization and compensation

WAI Work Ability Index

WHO World Health Organization

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1 Introduction

1.1 Background

Due to population ageing and decline of birth rates since the end of the 1960s in industrialised countries, the proportion of older workforce is constantly increasing. Furthermore, members of the baby boom generation (born between 1945 and 1964) increasingly reach retirement age, which poses serious strains on labour markets and pension systems. Already in 2001, the European Union (EU) has therefore set the goal to increase employment rates of individuals aged between 55 to 64 years to 50% (European Council, 2001). Along with other EU member states, the retirement age in Germany has consequently been gradually raised from 65 to 67 years (BMAS, 2014). Nevertheless, in Germany a shortage of 3.3 million skilled professionals is still estimated for 2040, especially in the medical and engineering sector (Ehrentraut, 2015, Böllhoff, 2017). Moreover in 2017, 13% of all newly accessed pensions were due to reduced earning capacity and more than 60% of all retirees left working life before reaching the official retirement age (DRV, 2017). Successful ageing at work has therefore reached high scientific and public interest due to (i) the high proportion of older workforce, (ii) the need to prevent further shortage of skilled professionals and (iii) to relieve pension systems.

Within the last decades there has further been an increased focus on psychosocial determinants in occupational health research caused by the strong relationship with stress-related diseases, work ability, sick leave and early retirement (Siegrist and Dragano, 2008b, van den Berg et al., 2009, Topa et al., 2018, Sundstrup et al., 2018). For example, psychosocial working conditions, such as high emotional and quantitative demands or low job control, have been associated with an increased risk for depression and cardiovascular disease (Siegrist and Dragano, 2008b, van der Doef and Maes, 1998, Theorell et al., 2015). Mental disorders in turn have been identified as the main reason for reduced earning capacity pension in Germany (gbe-bund, 2016). The relevance of psychosocial factors at work has additionally been underlined by the introduction of obligatory risk assessments for mental and psychological strain by the German government in 2013 (Arbeitsschutzgesetz, 2015).

Against this background, this dissertation aims to expand previous research on psychosocial determinants of work ability of older employees and healthy ageing at work using a series of different methodological approaches. Within the

introduction, different conceptualisations of ageing and their relation to work will be described from which an overarching framework of ageing in the work context will be developed (chapter 1.2). Based on this overarching framework, telomere length as a biological marker of age (chapter 1.3) and work ability as an age-sensitive work-related outcome (chapter 1.4) will be described. Furthermore psychosocial personal factors (chapter 1.5), working conditions (chapter 1.6) and their interactions (chapter 1.7) will be described and finally previous research results and research gaps on their association with telomere length (chapter 1.8) and work ability will be presented (chapter 1.9). In the last part of the introduction, the goals of this dissertation will be described (chapter 1.10).

1.2 Conceptualisations of ageing and their relation to work

From a biomedical perspective, ageing refers to the chronological decrease of cellular and physiological functioning leading to reduced fertility, increased morbidity and mortality (Gilbert, 2000). A variety of molecular mechanisms including genetic, epigenetic and metabolic alterations, loss of proteostasis, cellular senescence, stem cell exhaustion, changes in intercellular communication and mitochondrial dysfunction are underlying causes for this age-related decline (López-Otín et al., 2013). Telomere attrition, a form of genetic age-related alteration, will be discussed in more detail in a later part of this dissertation (chapter 1.3). A decline of cardiovascular (e.g. changes in blood pressure, increased ventricular afterload, decreased maximum heart rate, increased vascular stiffness), pulmonary (e.g. increased alveolar size, reduced elastic recoil, decreased chest wall compliance, vital capacity and diffusing capacity of carbon monoxide), renal (e.g. decline of glomerular filtration rate) and immune system functioning as well as reduced strength of the musculoskeletal system and changes in metabolism, endocrine functioning, hearing loss and decreased eyesight mark the decrease of physiological functioning (Khan et al., 2017). Furthermore, changes of neurologic functioning (e.g. anatomical changes, reduced dopamine activity and synaptic plasticity) go along with reduced processing speed and memory performance at higher age (Lara et al., 2015, Khan et al., 2017).

From a psychological point of view, ageing rather refers to a resource perspective (Freund, 2008). According to Hobfoll (1989), resources are defined as external (e.g. money, social support, advantageous working conditions) and internal conditions (e.g. health, knowledge, skills, self-efficacy) that help to accomplish personal goals or have another intrinsic value. In his "Conservation of Resources"

(COR) theory, he further outlines that a threat or actual loss of resources as well as the absence of resource gain after resource investment will lead to psychological stress. People therefore strive to prevent resource loss and to acquire new resources (Hobfoll, 1989). During lifetime, resources such as work experience and knowledge increase whereas other resources such as physical strength, health and some aspects of cognitive functioning decline by age (Khan et al., 2017, Salthouse, 2009, Zacher et al., 2018b, Baltes and Baltes, 1990). However, Paul and Margret Baltes proposed that with age, loss will finally outweigh the gain of resources and according to Hobfoll's COR theory this loss of resources will lead to psychological stress (Hobfoll, 1989, Baltes and Baltes, 1990).

Even though ageing is defined differently in the biomedical and psychological literature, both perspectives share common aspects. The biomedical aspect of chronological decline of cellular and physiological functioning might be translated as loss of resources within a psychological perspective of ageing. Furthermore the psychological perspective expands this biomedical aspect by acknowledging that also other non-physical resources may decline and that resources may even be gained throughout the course of ageing (Hobfoll, 1989, Baltes and Baltes, 1990).

The loss of resources or, in a biomedical sense, the loss of cellular and physiological functioning may lead to adverse work-related outcomes such as declined work ability in older workers (Kenny et al., 2008, Ilmarinen and Ilmarinen, 2015). However, previous research found that age is not necessarily related to work-related outcomes such as job performance (Ng and Feldman, 2008). Ng and Feldman (2013) argued that on the one hand health does not substantially decline before retirement age to contribute to significant differences between younger and older workers. On the other hand, increased knowledge and work experience may counterbalance potential negative effects of age-related loss of resources (Ng and Feldman, 2013). In addition, Salthouse proposed that negative effects of resource loss might especially be visible during maximum performance, which is however seldomly needed during daily work life (Salthouse, 2012).

Furthermore, both the biomedical as well as psychological perspectives acknowledge heterogeneity in the level and course of ageing due to relationships with personal and environmental factors (Kenny et al., 2008, Baltes and Baltes, 1990). For example, Baltes and Baltes differentiated between normal, optimal or pathological ageing (Baltes and Baltes, 1990). Taking up this proposition, Zacher has finally defined successful ageing at work as a positive deviation (i.e. optimal ageing)

from the average course of ageing in work-related outcomes (Zacher, 2015). Personal factors may for example include genetic prepositions, mental and physical health, behaviour and attitudes, whereas environmental factors may include societal, political, social as well as working conditions. As mentioned in the first chapter, this dissertation will however especially focus on psychosocial determinants and therefore only personal psychosocial factors and psychosocial working conditions will further be discussed. Both, psychosocial personal factors and working conditions may directly affect ageing in a biomedical (e.g. symptoms of the burnout syndrome have been associated with reduced telomere length; Ahola et al. (2012), Chmelar et al. (2017)) and psychological sense (e.g. resource loss in the sense of age-related cognitive decline might be reduced through high work complexity (Then et al., 2014)). Furthermore, they may moderate the relationship between ageing and work-related outcomes (e.g. individual action regulation strategies such as selection, optimization and compensation (SOC) have been proposed to counterbalance age-related loss of resources and might therefore alleviate an adverse relationship to work-related outcomes (Baltes and Baltes, 1990, Müller and Weigl, 2015, Moghimi et al., 2016)). In addition, they may also influence work-related outcomes independent from age, which is underlined by the fact that adverse working conditions can lead to reduced work ability in younger employees as well (Boström et al., 2012). Last but not least, psychosocial personal factors and working conditions might interact with each other on their relationship to ageing at work (e.g. SOC strategies might especially counterbalance age-related loss of resources if working conditions facilitate their use (Weigl et al., 2013)). Ageing at work is thus influenced by complex relationships between age, personal and environmental factors.

Derived from those propositions, the overarching framework of this dissertation is depicted in figure 1. To summarise, from a biomedical perspective cellular and physiological functioning declines by advancing age, whereas from a psychological perspective ageing is marked by the gain and loss of resources (arrow 1, figure 1). Those age-related changes may lead to adverse work-related outcomes (arrow 2, figure 1). However, personal psychosocial factors and psychosocial working conditions may i) affect cellular and physiological functioning and gain and loss of resources, ii) influence their effects on work-related outcomes and iii) influence work-related outcomes independent from age (arrows 3 and 4, figure 1). Finally yet importantly, personal psychosocial factors and psychosocial working conditions may moderate each other's effects (arrows 5 and 6, figure 1). However, since this

dissertation specifically aims to expand previous research on the role of personal psychosocial factors and psychosocial working conditions on ageing at work, only relationships depicted by arrows 3 – 6 will further be discussed.

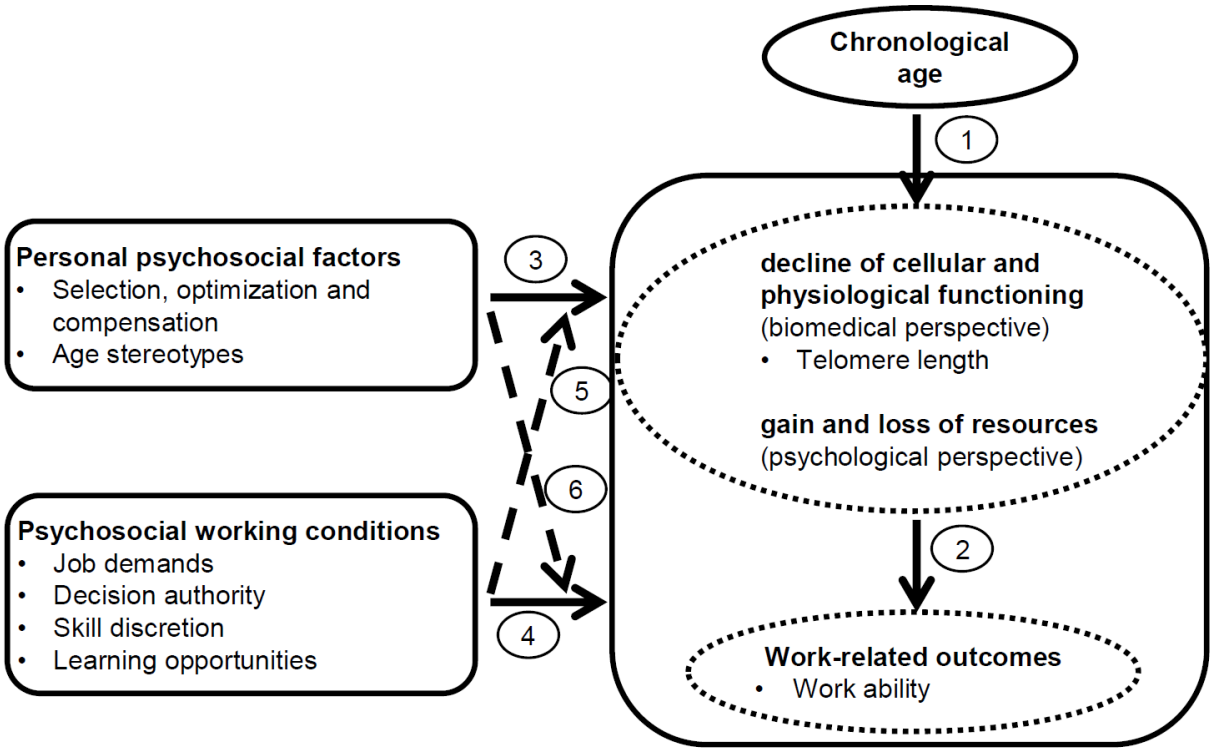

Fig. 1 Framework of ageing in the context of work (bullet points represent factors that will further be discussed in this dissertation; solid lines = direct effect; dashed line = moderation effect)

Without going further into detail to all relevant factors, I will concentrate my discussion on:

- telomere length as one biological marker of age (chapter 1.3)
- work ability as a work-related outcome (chapter 1.4)
- a selection of psychosocial personal factors (chapter 1.5) including SOC (chapter 1.5.1) and age stereotypes (chapter 1.5.2)
- psychosocial working conditions as environmental factors (chapter 1.6)

The special importance of those factors for the course of ageing at work will be outlined in the following chapters. Then, their potential relationships to each other depicted by arrows 3 – 6 will be described and in case of relevant research gaps investigated further within the scope of this dissertation.

1.3 Ageing from a biomedical perspective: The example of telomere length

Among researchers, telomere length has broadly been discussed as a biological indicator of ageing due to its continuous decline by age (Sanders and Newman, 2013, Wagner et al., 2016). Telomeres are uncoded, repetitive 5'-TTAGGG-3' sequences at the ends of chromosomes. They are about 10 to 15 kilobase pairs (kb) long and form a T-loop together with so-called shelterin complex proteins. During deoxyribonucleic acid (DNA) replication, the enzyme DNA polymerase cannot dock at the outer ends of chromosomes and is therefore not able to replicate those ends. Without telomeres, cells would therefore continuously loose genetic information and chromosome fusion may occur. However, telomeric ends ensure stability of chromosomes and protect for this continuous loss of genetic information. The enzyme telomerase with its reverse transcriptase subunit and ribonucleic acid (RNA) primer for TTAGGG sequences can initiate the replication of telomeric ends and thereby enables DNA polymerase to fill up missing sequences at the ends of chromosomes (Figure 1). Telomerase activity has especially been detected in germ, stem and cancer cells (for an overview on telomere structure and shortening: Zhao et al. (2014)). However, telomerase activity is very low in somatic cells and therefore telomeres of somatic cells shorten with every cell division until they reach the so called Hayflick limit and pass over into cellular senescence or even apoptosis (Zhao et al., 2014, Rizvi et al., 2014). Consequently, the shortening of telomeres is a normal ageing process and telomere length has been suggested as a potential marker for biological age (Sanders and Newman, 2013). A number of determinants of telomere length have been proposed. Oxidative stress can lead to single-stranded breaks in telomeric sequences promoting telomere shortening during cell division (Zhang et al., 2016). Furthermore, inflammation correlates with rapid clonal immune cell proliferation, which in turn leads to telomere attrition (Zhang et al., 2016). In addition various genetic, epigenetic, dietary and environmental factors as well as psychological stress have been associated with telomere length (Freitas-Simoes et al., 2016, Kim et al., 2012, Mangino et al., 2012, Melicher et al., 2015, Hunt et al., 2008, Diez Roux et al., 2009, Mathur et al., 2016, Zhang et al., 2013). Researchers have hypothesized that telomere attrition would lead to increased morbidity and mortality, but previous research findings on this issue are equivocal (Sanders and Newman, 2013). However, telomere length marks age-related decline

of cellular and potentially physiological functioning and therefore relates to the biomedical perspective of ageing (Sanders and Newman, 2013, Wagner et al., 2016). Furthermore, previous research suggests heterogeneity in the level of telomere shortening inter alia due to psychological stress (Mathur et al., 2016). Telomere length might thus be a useful objective measure to study the role of psychosocial personal factors and working conditions on healthy ageing from a biomedical point of view.

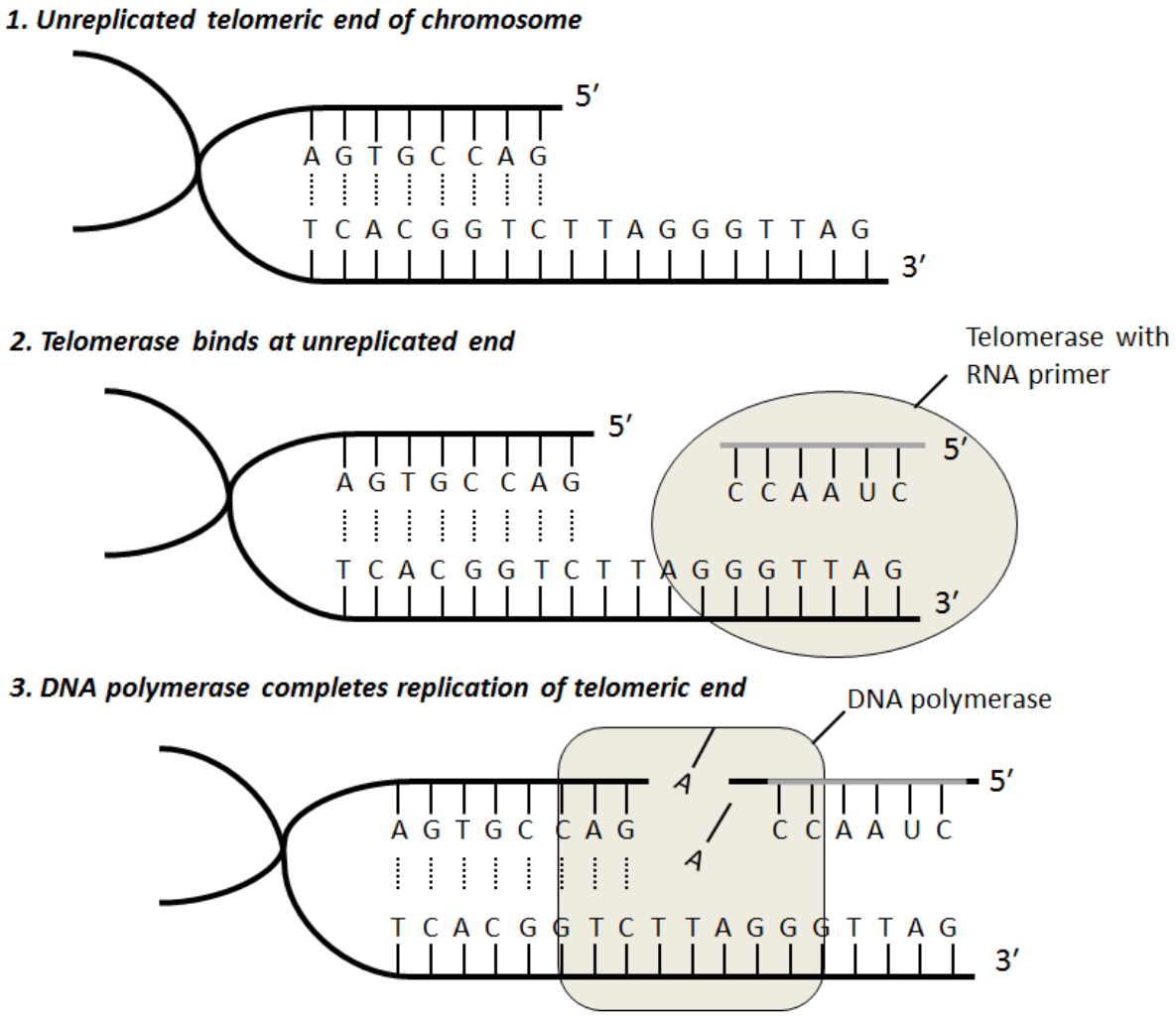

Fig. 2 Replication of telomeres

1.4 Age sensitive work-related outcomes: The example of work ability

Since work ability is highly predictive for sick leave and disability pensions (Ahlstrom et al., 2010, Lundin et al., 2017, Tuomi et al., 1997) and is often marked by an age-related decline (van den Berg et al., 2009, Camerino et al., 2006), work ability functions as an important tool to study successful ageing at work. The concept of work ability, developed by Ilmarinen and Tuomi, describes the interplay between

personal resources and working conditions to perform the tasks at work successfully (Ilmarinen, 2001, Ilmarinen and Tuomi, 1992). In other words, good work ability refers to a good fit between personal resources and ones working conditions. Personal resources may thereby include (i) physical and mental health, (ii) skills and expertise, (iii) values, attitudes and motivation that are relevant for work. Working conditions may include (i) physical and mental demands, (ii) work organization and community and (iii) work environment (Ilmarinen, 2001, Hasselhorn and Freude, 2007). The fit between personal resources and working conditions can further be influenced by social (e.g. family, friends) and societal (e.g. culture, policies, globalization) structures (Ilmarinen and Ilmarinen, 2015). The *Work Ability Index* (WAI) is a widely used instrument for self-assessment of work ability (Hasselhorn and Freude, 2007). It is characterized by good predictive validity and correlates with sick leave, obtaining disability pension and health-related quality of life (Ahlstrom et al., 2010, Lundin et al., 2017, Tuomi et al., 1997). Despite some inconsistent results, the majority of previous studies implied that work ability decreases by age (van den Berg et al., 2009, Camerino et al., 2006). According to the definition of work ability, this age-related decline has been explained by an increasing imbalance between personal resources and working conditions (Ilmarinen and Ilmarinen, 2015). On the one hand, personal resources change during lifetime and loss will finally outweigh the gain of resources as outlined in chapter 1.2 (Baltes and Baltes, 1990, Ilmarinen, 2001). On the other hand, also working conditions constantly change due to technological advancements, globalisation and digitalisation, which, according to Ilmarinen, older workers may find it increasingly harder to adapt to (Ilmarinen, 2001). Work ability might thus be a useful subjective, age-sensitive measure to study the role of psychosocial personal factors and working conditions for older employees.

1.5 Personal psychosocial factors

A detailed discussion of all personal psychosocial factors (e.g. future time perspective (Rudolph et al., 2018), social identity (Zacher et al., 2018a), family situation (Henkens, 1999)) that may potentially influence ageing and work-related outcomes of older employees would by far exceed the scope of this dissertation. Instead, I will primarily focus on SOC strategies as coping strategies for age-related loss of resources and on age stereotypes as common beliefs and attitudes towards age and older individuals. The central role of specifically those factors for an ageing workforce will further be described in the following sections.

1.5.1 Selection, optimization and compensation

As mentioned above (chapter 1.2), ageing from a psychological perspective is conceptualised in the sense of loss and gain of resources (Freund, 2008). Against the background of increasing loss of resources with higher age, effective allocation of remaining resources seems essential for successful ageing (Baltes and Baltes, 1990). A model encompassing individual strategies for effective allocation of resources has been introduced by Baltes and Baltes, called the model of selection, optimization and compensation (SOC; Baltes and Baltes (1990), Baltes and Baltes (1980)).

According to Baltes and Baltes (1990, 1980), selection thereby describes a goal setting process instead of pursuing multiple goals, which may either be based on preference, necessity and importance (elective selection) or based on the depletion of resources (loss-based selection). Optimization involves behaviours that increase and improve resources and coordinate resource use allowing for better achievement of selected goals. When resources decline, compensation includes the offset of those lost resources by other resources including psychological or technological means. The pianist Artur Rubinstein has served as a prominent example for the use of SOC since Baltes and Baltes (1990) have interpreted his statement in an interview on how he was able to successfully give concerts until high age despite age-related weaknesses as follows: “First, he reduces his repertoire and plays a smaller number of pieces (selection); second, he practices these more often (optimization); and third, he slows down his speed of playing prior to fast movements, thereby producing a contrast that enhances the impression of speed in the fast movements (compensation)” (Baltes and Baltes, 1990).

Freund and Baltes (2000) further proposed that those three strategies act in a combined and coordinated manner. For example, optimization of resources may especially result in successful development when they correspond to selected goals (Freund and Baltes, 2000). Interaction effects between selection, optimization and compensation may therefore be possible, but have only rarely been investigated yet (Moghimi et al., 2016).

In the work context, the use of SOC strategies has been found to be associated with positive work-related outcomes such as job performance, job satisfaction and job engagement (Moghimi et al., 2016). Interactions between the SOC sub-strategies was investigated by one first study, which found that selection was only positively related to higher work engagement when also optimization as well

as compensation were high (Zacher et al., 2015). Furthermore, first intervention studies in the work context showed that a training of SOC strategies could result in improvements of physical and mental well-being (Becker et al., 2017, Müller et al., 2016).

To summarise, SOC is attributed a role on allocation of resources (Baltes and Baltes, 1990) and consequently on occupational well-being and work ability (Moghimi et al., 2016). SOC is thus suggested to represent an important psychosocial personal determinant for successful ageing at work (Zacher, 2015) and its role will therefore further be investigated within this dissertation.

1.5.2 Age stereotypes

Age stereotypes are defined as common beliefs or expectations regarding characteristics and behaviours of particular age groups (Finkelstein et al., 2015). Within this dissertation, age stereotypes will specifically relate to stereotypes towards older individuals. Older workers are often confronted with stereotypes of being less flexible, productive and having a lower ability to learn. Even though the accuracy of such age stereotypes cannot be scientifically confirmed, those erroneous beliefs are commonly held in the work context (Posthuma and Campion, 2009). Younger age and lower educational status have been shown to be associated with stronger negative age stereotypes (Gluth et al., 2010, Kite et al., 2005, Spangenberg et al., 2018, Tajfel and Turner, 1986). Furthermore, cross-cultural variance is suggested by previous research with inhabitants of European and North-American countries holding more favourable stereotypes towards older age groups than inhabitants of East, South and South-East Asia (North and Fiske, 2015).

If age stereotypes are held by others, e.g. younger workers or supervisors, they may result in behavioural changes when dealing with older workers. In this context, age stereotypes have even been associated with discriminatory attitudes and behaviours including reduced willingness to employ or promote older workers (Abrams et al., 2016, Chiu et al., 2001). When growing old, stereotypes towards older age groups may become self-stereotypes due to continuous internalization throughout lifetime (Levy, 2009). Those self-stereotypes may then act as self-set constraints and affect older workers according to self-fulfilling prophecy (Levy, 2003). Furthermore, older workers may think or be aware of stereotypes towards their own age group that are held by other age groups, also called meta-stereotypes (Finkelstein et al., 2015). Being concerned or feeling threatened to confirm negative

age meta-stereotypes results in a stereotype threat situation in which psychological and physiological stress processes may adversely affect performance or may lead to avoidance of related domains (Finkelstein et al., 2015, Schmader et al., 2008, Davies et al., 2002).

In their systematic review about the relationship of perceptions on ageing with physical and mental health and functioning, Warmoth et al. (2016) gathered the results of previous studies on older individuals aged 60 years and older. In those studies negative perceptions on ageing (a term including stereotypic attitudes) held by older individuals themselves was related to ill health, reduced memory, cognitive and physical performance, unhealthy behaviour and eventually to increased mortality. The authors concluded that those relationships are likely to be bi-directional. On the one hand internalisation processes may induce adverse effects of negative perceptions on ageing but on the other hand also reduced physical and cognitive functioning and health may have induced negative perceptions on ageing (Warmoth et al., 2016). A meta-analysis by Horton et al. (2008) and a follow-up by Lamont et al. (2015) have investigated the effects of meta-stereotype threat studied in experimental research. In this experimental research, stereotypic manipulations were conducted to induce stereotype threat. Within the meta-analyses, small to medium pooled effect sizes were calculated for those stereotypic manipulations indicating that stereotype threat results in decreased memory performance among older individuals (Horton, 2008, Lamont et al., 2015). This experimental research hints to a causal relationship between stereotypes and reduced performance in the stereotype to performance direction. Again, this research was mainly conducted with participants above 60 years of age, lacking a focus on the workplace. In the context of work, single studies have associated negative age (meta-) stereotypes with reduced job satisfaction, work engagement or increased retirement intentions (Kulik et al., 2016, von Hippel et al., 2013, Hofstetter and Cohen, 2014). Those previous research results highlight the need to consider age stereotypes as psychosocial personal determinants for work-related outcomes while studying an ageing workforce. However, to the best of my knowledge a systematic overview about related research in the work context is missing. Therefore, a systematic review about the consequences of age stereotypes on older employees has been conducted within the scope of this dissertation (chapter 4).

1.6 Psychosocial working conditions

A vast amount of occupational health research is dealing with the role of psychosocial working conditions on employees' health, well-being and work ability (e.g. de Lange et al., 2003, Bakker and Demerouti, 2007). Psychosocial working conditions are most often contextualized through established job stress models such as the Job Demand-Control (Karasek, 1979) and the Effort-Reward-Imbalance model (Siegrist, 1996). The *Job Demand-Control (JDC) model* by Karasek (Karasek, 1979) states that the combination of demands and control results in four different types of jobs. A passive job occurs when job demands and job control are low. An active job instead is defined when job demands and job control are high. If job demands are low but job control is high, this results in a low strain job and if job demands are high but job control is low, this results in a high strain job. Thus, on the one hand high job demands can induce job strain if the employee does not have enough job control to meet those demands. On the other hand, in combination with high job control it can induce high activity levels, which is associated with favourable outcomes including job satisfaction. In the JDC model job demands typically address workload and job-related conflicts, whereas job control typically addresses decision latitude (Karasek, 1979). Later on social support at work was added as a further factor to the JDC model. In this modified *Job Demand-Control-Support (JDCS) model*, low levels of social support are suggested to further enhance the negative effects of high job demands and low job control (Johnson and Hall, 1988). A vast amount of research has then tested the propositions of the JDC/S model. On the one hand high job demands, low job control and low social support were associated with increased risks for cardiovascular disease, psychological disorders, sickness absence and early retirement intentions (van der Doef and Maes, 1998, Theorell et al., 2015, Elovainio et al., 2005, Ishizaki et al., 2006). On the other hand, de Lange et al. (2003) stated that longitudinal research "provided only modest support for the strain hypothesis of the DC/S model" (de Lange et al., 2003), meaning that only 42% of high quality longitudinal studies found additive or multiplicative effects of job demands, control and social support. All other studies only provided evidence for either one or two components of the JDC or JDCS model (de Lange et al., 2003).

To extend the JDC/S model by other job characteristics, the research group around Demerouti, Schaufeli and Bakker have developed the Job Demands-Resources (JDR) model (Bakker and Demerouti, 2007, Demerouti et al., 2001). The JDR model thereby reflects an overarching framework of job characteristics that can

either be classified as demands or resources and respectively contribute to job strain or motivation (Bakker and Demerouti, 2007). In contrast to the JDC model, job demands are formulated more broadly. Depending on the type of job, they include all physical, cognitive, social, emotional and organizational aspects of work, which are related to increased job strain. Job resources instead help individuals to pursue their work goals, develop new skills and knowledge and may buffer negative effects of job demands. Therefore job resources may not only include job control, social support and rewards but also other job characteristics such as leadership quality, role clarity or development and learning opportunities. In the first place the JDR model was used to explain the occurrence of burnout with job demands leading to increased exhaustion and lack of resources leading to disengagement (Demerouti et al., 2001). A few years later, the model was extended by stating that high job demands will lead to burnout, whereas job resources will increase work engagement (Schaufeli and Bakker, 2004). Furthermore, burnout and engagement were proposed to serve as mediators for a comprehensive variety of negative and positive outcomes such as physical and mental illnesses, turnover intentions, performance, satisfaction or work ability (Schaufeli and Taris, 2014). The theory of the JDR model thereby suggests that job demands and job resources act independently by two distinct psychological processes. Whereas job demands are proposed to be associated with burnout leading to reduced health through a health impairment process, job resources are proposed to be associated with increased work engagement leading to increased job satisfaction through a motivational process (Schaufeli and Bakker, 2004). This theory of dual processes has been repetitively proven by previous research (Schaufeli and Bakker, 2004, Hakanen et al., 2008, Bakker and Demerouti, 2007). However, the definition of job resources also suggests that job resources may buffer the negative effects of job demands. Such interactive effects between job resources and job demands were also found in previous research (Bakker and Demerouti, 2007, Bakker et al., 2005, Xanthopoulou et al., 2007). In sum, the JDR model provides a very flexible framework regarding potential job demands, resources and outcomes that can be studied in occupational research and helps to explain the occurrence of reduced mental health, job satisfaction, sickness absence and turnover intentions in relation to work (Schaufeli and Taris, 2014).

Employees' age has been proposed to interact with psychosocial working conditions regarding their relationship to health, well-being and work-related outcomes (Zacher and Schmitt, 2016). As was summarised by Zacher and Schmitt

(2016), previous research provides evidence that certain working conditions are more important for older employees, other working conditions are more important for younger employees, and that those differences even depend on the outcome under investigation. In addition, psychosocial working conditions might even have an impact on ageing processes (Freude et al., 2010). From a psychological point of view, favourable working conditions are considered as resources (Bakker and Demerouti, 2007), which according to Hobfoll's COR theory contribute to reduced stress (Hobfoll, 1989) and are according to SOC theory associated with optimal ageing (Baltes and Baltes, 1990). Furthermore, unfavourable working conditions might lead to job strain and deterioration in health (van der Doef and Maes, 1998, Schaufeli and Taris, 2014). From a biomedical perspective, psychosocial working conditions might thus be related to telomere length mediated by stress processes. Within this dissertation, the role of quantitative job demands and job resources including decision authority (i.e. job control), skill discretion (i.e. development opportunities) and learning opportunities on work ability of older employees and telomere length will further be assessed.

1.7 Interaction between psychosocial personal factors and working conditions

Besides direct effects of psychosocial personal factors and working conditions, they may also interact in their role on healthy ageing and work-related outcomes (Zacher, 2015). Different models around functioning and work have addressed such potential moderation effects. For example, the *International Classification of Functioning, Disability and Health* (ICF) released by the *World Health Organization* conceptualised functioning as a "dynamic interaction between a person's health condition, environmental factors and personal factors" (WHO, 2013). In the work context, the ICF defines functioning by the maintenance and progress in the job (WHO, 2017) and therefore relates to work ability, sickness-absence or occupational disability. This conceptualisation implies that psychosocial personal factors and working conditions do not only have separate effects but that also moderated processes between those variables should be taken into account. Furthermore, the definition of work ability as the interplay between personal resources and working conditions to perform successfully the tasks at work (Ilmarinen, 2001, Ilmarinen and Tuomi, 1992) also implies such interactive processes. Moreover, the JDR model is often expanded by personal resources. Within the scope of this expansion, it has

been acknowledged that job demands, job resources and personal resources do not only separately impact occupational well-being but that personal resources may also moderate the effects of job demands and job resources (Schaufeli and Taris, 2014). The definitions of functioning, work ability and expansion of the JDR model by personal resources demonstrate the need to take interactions between psychosocial personal factors and working conditions into account when analysing their effects on older employees.

For instance, certain working conditions may be needed to apply SOC strategies successfully. For example, decision authority may act as a prerequisite to be able to select goals based on own preferences and to compensate lost resources by alternative means (Weigl et al., 2013). A substantial part of this dissertation will therefore concentrate on potential interaction effects between SOC and working conditions.

1.8 Relationships between telomere length and psychosocial personal factors and working conditions: Previous research and research gaps

Two studies found that emotional exhaustion and depersonalisation, two facets of the burnout syndrome, are associated with shorter telomeres (Ahola et al., 2012, Chmelar et al., 2017). This indicates that work-related factors might be related to telomere length. Nevertheless, whether psychosocial working conditions are associated with telomere length has only been investigated by a few studies. However, those studies did not find direct associations between psychosocial working conditions in terms of job control, job demands and social support and telomere length (Chmelar et al., 2017, Fujishiro et al., 2013). In addition, work stress in a sample of teachers in South Africa was not associated with telomere length (von Känel et al., 2015). To summarise, previous research indicates only a minor role of psychosocial working conditions (Chmelar et al., 2017, Fujishiro et al., 2013). However, this research has mainly focused on working conditions of the JDC model and evidence on associations to other working conditions (e.g. learning opportunities) remains scarce. Since previous research results indicate that psychological stress may lead to telomere shortening (Mathur et al., 2016), we have argued however that learning opportunities at work might decelerate telomere shortening through reduction of stress (Weber et al., 2019b). In more detail, new resources (e.g. skills

and knowledge) might develop from learning opportunities at work, which might according to COR theory play a role in resistance to stress (Hobfoll, 1989).

Furthermore, the use of SOC-strategies is proposed to be helpful for adaptation to age-related loss of resources (Freund, 2008, Baltes and Baltes, 1990). Age-related loss of resources might otherwise lead to stress according to COR theory (Hobfoll, 1989) and therefore to increased telomere shortening (Mathur et al., 2016). The use of SOC strategies might therefore be positively associated with telomere length. However, to the best of my knowledge, this has not been investigated so far.

In addition, we have argued that learning opportunities might be needed to apply SOC strategies and that learning opportunities might best be used by employees employing SOC strategies. Thus, interaction effects between SOC and learning opportunities on their association with telomere length might be expected (Weber et al., 2019b). Relationships between learning opportunities, SOC and their interaction on telomere length were therefore investigated within the scope of one study of this dissertation (chapter 2).

Regarding age stereotypes, the findings of one first study on a sample of community dwelling older individuals suggests a negative association between negative age stereotypes and telomere length (Pietrzak et al., 2016).

1.9 Relationships between work ability and psychosocial personal factors and working conditions: Previous research and research gaps

In their systematic review, van den Berg et al. (2009) have summarised study results regarding effects of various personal and work related factors on work ability until the year 2006. It appeared that high mental demands, low decision authority and low skill discretion at work are accompanied by decreased work ability (van den Berg et al., 2009). Younger studies confirmed those relationships and reported positive relationships between social support at work and work ability (Leijon et al., 2017, Converso et al., 2018). Those studies involved age diverse as well as study samples with exclusively older workers and included cross-sectional as well as longitudinal study designs. Results regarding a connection between SOC or age stereotypes on the one hand and work ability on the other hand were not reported in the review of van den Berg et al. (2009). However, younger cross-sectional studies found use of SOC strategies to be positively correlated with work ability among older employees (Müller et al., 2012, Müller et al., 2013, von Bonsdorff et al., 2014, Weigl et al., 2013).

However, studies on longitudinal relationships between SOC and work ability remain scarce (Müller and Weigl, 2015) and will be addressed by one study of this dissertation (chapter 3). In addition, to the best of my knowledge, the relationship between age stereotypes and work ability has not been investigated so far. However, believing negative stereotypes towards older workers such as being less flexible or productive may lead to self-imposed constraints among older employees by reducing confidence in own abilities (Levy, 2003, Maurer et al., 2008). Negative age stereotypes may therefore be negatively associated with perceived work ability among older employees.

Apart from those direct effects, SOC and working conditions were also shown to interact in their relationship to work ability. SOC strategies and decision authority seem to mutually enhance their positive effects on work ability (Riedel et al., 2015, Weigl et al., 2013). Moreover, first study results indicate that negative effects of high work demands may partially be attenuated by the use of SOC strategies; however statistical significance was missed for this association (Riedel et al., 2015). Those results suggest that SOC use may enhance the positive effects of job resources and may buffer the negative effects of job demands. At the same time, the positive effect of SOC may further be reinforced by favourable working conditions. However, those interaction effects were weak and only observed within cross-sectional studies (Riedel et al., 2015, Weigl et al., 2013). Therefore, longitudinal study designs and intervention studies are necessary to confirm those preliminary results and to shed light on long-term effects and causal relationships. A study being part of this dissertation has thus investigated potential interactions between SOC and psychosocial working conditions on work ability by means of a longitudinal study design (chapter 3).

1.10 Aims of dissertation

The dissertation aims to expand previous research on psychosocial determinants of work ability and healthy ageing at work. This topic is of high public health relevance due to the increasing share of older workforce and the high economic costs of work disability and early retirement. In this sense, the dissertation adds cross-sectional and longitudinal findings regarding relationships of SOC, working conditions and their interactions on work ability and telomere length. Furthermore, the effects of age stereotypes on older workers will be assessed by the use of a systematic literature review. This may help to unravel main and interactive

effects of important personal psychosocial factors and working conditions on ageing at work and may therefore be a first step to develop well-tailored interventions to promote labour participation of older workforce. Those research findings will be presented within the scope of three published original research studies. An overview on the topics of those studies can be found in table 1.

As was outlined by previous parts of this introduction, telomere length has been suggested as a potential marker for biological age (Sanders and Newman, 2013). Even though perceived stress in general (Mathur et al., 2016) and burnout (Ahola et al., 2012, Chmelar et al., 2017) have adversely been related to telomere length, research on work-related psychosocial determinants of telomere length is scare. The first study will therefore assess associations of SOC, learning opportunities and their interaction with telomere length within a cross-sectional study among employees in geriatric care. This study was approved by the Ethics Committee of the Medical Faculty of the Ludwig-Maximilians-University of Munich (no.99-15).

Direct and interactive effects of SOC and working conditions will also be analysed in the second study. Findings of previous research repeatedly pointed to the role of SOC on older workers' work ability and also indicated moderation effects by working conditions (Müller et al., 2012, Müller et al., 2013, von Bonsdorff et al., 2014, Weigl et al., 2013, Riedel et al., 2015). However, evidence on long-term interaction effects is missing. In addition, SOC theory proposes that the single SOC sub-strategies act in a combined and coordinated manner (Freund and Baltes, 2000), which has however rarely been investigated yet (Moghimi et al., 2016). The second study therefore aims to explore the main and interactive effects of SOC, SOC sub-strategies and psychosocial working conditions on older employees' work ability by the use of a longitudinal study design within the German lidA ("Leben in der Arbeit" – living at work) cohort study. The lidA cohort study was approved by the ethics committee of the University of Wuppertal (December 5th, 2008).

Turning to the effects of age stereotypes on older workers, the third study of my dissertation will comprise a systematic literature review about this topic. Outside the context of work, age stereotypes seem to play role on older individuals' health and performance (Lamont et al., 2015, Warmoth et al., 2016). Furthermore, age stereotypes have been shown to exist at work attributing negative characteristics such as lower productivity and adaptability to older employees (Posthuma and Campion, 2009). It is therefore conceivable that stereotypes towards older workers

may lead to reduced work ability and early retirement among older employees. However and to the best of my knowledge, existing research on individual consequences of age stereotypes at work has not systematically been gathered yet. The third study of this dissertation will therefore cover a systematic review on individual consequences of age stereotypes on older employees.

Table 1 Overview on research papers included in the dissertation

Study	Chapter	Study design	Determinant	Outcome	Reference
1	2	Cross-sectional	SOC Working conditions	Telomere length	Weber et al., 2019b
2	3	Longitudinal	SOC Working conditions	Work ability	Weber et al., 2018
3	4	Systematic review	Age stereotypes	Various	Weber et al., 2019a

2 Learning on the job, the use of selection, optimization, and compensation strategies, and their association with telomere length as an indicator of biological aging. Weber, J., Jörres, R., Kronseder, A., Müller, A., Weigl, M., Chmelar, C. International Archives of Occupational and Environmental Health 92(3): 361-370 (2019)

3 Prognostic effects of selection, optimization and compensation strategies on work ability – Results from the representative lidA cohort study on work, age, and health in Germany. Weber, J., Müller, A., Stiller, M., Borchart, D. International Archives of Occupational and Environmental Health, 91(8): 1061-1071 (2018)

4 Individual consequences of age stereotypese on older workers – A systematic review. Weber, J., Angerer, P., Müller, A. Zeitschrift für Gerontologie und Geriatrie, 52(Suppl 3): 188-205 (2019)

5 Discussion

Against the background of demographic change, the topic around successful and healthy ageing at work has reached high public health relevance. Within this topic especially psychosocial determinants have obtained high public and scientific interest due to their strong relationship with work ability, sick leave and early retirement (DRV, 2015, Siegrist and Dragano, 2008a, van den Berg et al., 2009, Topa et al., 2018, Sundstrup et al., 2018). Within this dissertation, I have therefore aimed to expand previous research on a variety of potential psychosocial determinants of work ability and healthy ageing at work. I was especially interested in the role of SOC, age stereotypes and psychosocial working conditions and chose to investigate their relationships with telomere length and work ability. To investigate those relationships, cross-sectional data of a sample of employees working in the health care sector was used as well as longitudinal data of a large representative cohort of older employees contributing to the German social security system. Furthermore, previous research on age stereotypes and their consequences on older workers was identified and summarised within a systematic literature review. The samples and results of those studies are shortly described in table 2.

Table 2 Description of studies

Study	Study sample	Measures	Results
1 (Weber et al., 2019b)	140 employees in geriatric care in Germany, M_{age}=44.10 (SD=12.39)	Determinants: selection, optimization and compensation, working conditions (learning opportunities) Outcome: telomere length	• Use of compensation was negatively associated with telomere length • Learning opportunities, SOC sub-strategies and SOC sum-score were not directly associated with telomere length • Interaction between optimization and learning opportunities: use of optimization was positively associated with telomere length when learning opportunities were high
2 (Weber et al., 2018)	lidA cohort study, representative for employees contributing to German social security system and born in 1959 and 1965	Determinants: selection, optimization and compensation, working conditions (job demands, decision authority, skill discretion) Outcome: work ability	• SOC sum-score and use of compensation was positively associated future work ability • All other SOC sub-strategies were not directly associated with future work ability • Job demands were negatively associated and decision authority and skill discretion were positively associated with future work ability • Interaction between loss-based selection and decision authority: loss-based selection was positively associated with future work ability when decision authority was high • Interaction between optimization and job demands: Optimization was positively associated with future work ability when job demands were high • Interactions among SOC sub-strategies were not observed
3 (Weber et al., 2019a)	Systematic review	Determinant: age stereotypes Outcomes: intentions to retire and resign, self-efficacy, job satisfaction, performance, work engagement, learning and development intentions	• Consistent evidence that negative stereotypes about older age groups are negatively associated with work engagement, learning and development intentions and positively associated with intentions to retire and resign • Mixed evidence that negative stereotypes about older age groups are associated with self-efficacy, job satisfaction and performance

In the following parts of the discussion the results will systematically be described and interpreted per determinant (chapter 5.1 and 5.2) and combined regarding interactions between SOC and working conditions (chapter 5.3). Then, a discussion of strengths and limitations (chapter 5.4) as well as implications (chapter 5.5) will follow.

5.1 Effects of personal psychosocial factors

5.1.1 Selection, optimization and compensation

As described in Weber et al. (2019b), the SOC sub-strategies selection and optimization were not directly associated with telomere length of leucocytes among a sample of employees working in geriatric care. Instead, compensation was negatively related to telomere length. Furthermore, a trend to a negative association between the SOC sum-score and telomere length was observed. However, the latter association did not attain statistical significance (Weber et al., 2019b). Both associations were rather unexpected, because the use of SOC is generally proposed to support adaptation to resource loss (Baltes and Baltes, 1990). Resource loss might otherwise lead to increased stress according to Hobfoll's COR theory (Hobfoll, 1989). As psychosocial stress was shown to be associated with accelerated telomere shortening (Mathur et al., 2016), a positive association between SOC and telomere length would have been logical. However, the study design was only cross-sectional. Therefore, causality can neither be assumed, nor the possibility of reverse causation be excluded. We have therefore argued that compensation strategies might have been applied to respond to age-related loss of resources, explaining the adverse association between SOC and telomere length (Weber et al., 2019b).

As described in Weber et al. (2018), longitudinal data of the German lidA cohort study was used to analyse prospective effects of SOC on work ability of older employees. This cohort comprises a representative sample of employees born in 1959 and 1965, who contribute to the German social security system (Hasselhorn et al., 2014). In contrast to the results of the study on telomere length (Weber et al., 2019b), this study observed a positive relationship of the SOC sum-score to work ability after three years of follow-up. Among the single SOC sub-strategies, compensation was associated with work ability, but all other SOC sub-strategies were not related to work ability. Those analyses were not controlled for baseline work ability, reverse causation cannot be excluded. When those analyses were repeated under control for baseline work ability, a lagged positive association between the use

of compensation and work ability was found. However, there was no lagged association between the SOC sum-score and work ability. Even though, associations between SOC and work ability were in the proposed direction, those associations were rather weak. In addition, interactive effects among SOC sub-strategies on employees' work ability were assessed, but no meaningful interactions were observed (Weber et al., 2018).

Those results suggest that of all three SOC sub-strategies only compensation might directly play a role for ageing at work. This result seems surprising regarding that SOC theory proposes "orchestration of selection, optimization and compensation" (Freund and Baltes, 2000). In line with the orchestration proposition most studies so far have investigated SOC as a whole and did neither analyse the effects of selection, optimization and compensation separately nor potential interactions among those three sub-strategies (Moghimi et al., 2016). However, results of some other studies also suggested a role of optimization on work ability, work engagement and emotional well-being (Wiese et al., 2000, Riedel et al., 2015, Zacher et al., 2015) but no effects of selection. In contrast, another study has also found selection to be related to work ability (Sottimano et al., 2019). Two further studies have examined interactive effects among selection, optimization and compensation, but results were mixed (Freund and Baltes, 1998, Zacher et al., 2015). So far, the current state of research has therefore been inconclusive regarding the orchestration proposition and rather points to a separate effect of compensation and possibly optimization and selection. Furthermore, effects of SOC and its sub-categories may depend on other personal characteristics and external circumstances (Moghimi et al., 2016) of which the latter will be discussed in terms of psychosocial working conditions in chapter 5.3.

5.1.2 Age stereotypes

As described by Weber et al. (2019a), previous research results on the impact of age stereotypes on older workers were gathered and summarised within the scope of a systematic review. During literature search, 25 relevant articles were identified, which have investigated the role of age stereotypes on a variety of different outcomes among workers aged 45 years and above. Consistent evidence was thereby found regarding a negative association between negative stereotypes towards older workers and work engagement (5/5 studies), learning and development intentions (4/4 studies). Furthermore, under consideration of mediators such as occupational future time perspectives or job content plateau, consistent

evidence was also found for a positive relationship between negative stereotypes towards older workers and increased intentions to retire (6/7 studies) or to resign (3/3 studies). Only inconsistent evidence was found for relationships between age stereotypes and performance, job satisfaction or self-efficacy. No study was found investigating a relationship between age stereotypes and work ability. Due to heterogeneous study quality and different operationalisation and measurement of stereotypes, it was not meaningful to perform a meta-analysis. However, the results of this systematic review indicate that negative age stereotypes might have various consequences on older workers including reduced work engagement and learning and development intentions as well as increased intentions to retire and resign (Weber et al., 2019a). Previous research suggests that stereotypes can operate by different pathways. On the one hand, individuals may expect others to hold negative stereotypes about their age-group (age meta-stereotype), which may lead to concerns to confirm those stereotypes (Finkelstein et al., 2015). This stereotype threat may then induce stress (Schmader et al., 2008) and possibly avoidance of relevant domains (Davies et al., 2002). On the other hand, it is likely that negative stereotypes towards older age groups are continuously internalised throughout life and become so called self-stereotypes in higher age (Levy, 2003). This internalisation may than even unconsciously shape expectations on own abilities and therefore affect older workers according to self-fulfilling prophecy (Levy, 2003, Hansen and Wänke, 2009). Results of studies that were included in the systematic review support both pathways, even though age meta-stereotypes were more often investigated than own age stereotypes (Weber et al., 2019b).

5.2 Effects of psychosocial working conditions

Among the sample of employees in geriatric care, learning opportunities tended to be positively related to telomere length, but this association missed statistical significance (Weber et al., 2019b). This result suggests a minor role of learning opportunities for biological ageing. This is in line with findings of previous research, which found that also other psychosocial working conditions including job demands, decision authority and social support as well as work stress were not directly associated with telomere length (Chmelar et al., 2017, Fujishiro et al., 2013, von Känel et al., 2015). However, learning opportunities enable the gain of new resources, which should according to Hobfoll's COR theory reduce stress (Mikkelsen et al., 1999, Hobfoll, 1989). Due to the evidence that psychological stress is

associated with reduced telomere length (Mathur et al., 2016), we expected that learning opportunities would be positively related with telomere length (Weber et al., 2019b). Nevertheless, learning opportunities may under certain preconditions increase workload and therefore work stress (Glaser et al., 2015). Furthermore, especially older workers might, according to socioemotional selectivity theory, be less interested in knowledge acquisition due to reduced future-oriented perspectives (Carstensen et al., 1999). In both cases, potential positive effects of learning opportunities would therefore be obscured. Furthermore, sample size in this study was rather small and in light of the broad range of potential other determinants of telomere length (Rizvi et al., 2014, Freitas-Simoes et al., 2016, Kim et al., 2012), it is reasonable that only small effects with low statistical significance are found.

Using the lidA cohort sample, relationships between work ability and psychosocial working conditions including quantitative demands, decision authority and skill discretion were analysed among older employees. If analyses were adjusted for baseline work ability, a lagged negative effect of quantitative demands and, to a smaller extend, a lagged positive effect of decision authority was found. If analyses were not adjusted for baseline work ability, also skill discretion was positively related to work ability.

Altogether, the results of the lidA cohort study suggest that high quantitative job demands predict lower levels of work ability among older employees. This finding is in line with results of previous studies about relationships between job demands and work ability (van den Berg et al., 2009). Furthermore, it can be interpreted in terms of the JDC model, which states that high job demands can lead to job strain (Karasek, 1979). However, decision authority was only weakly associated with work ability (Weber et al., 2018). The minor role of decision authority on work ability of employees within the lidA cohort study contrasts the assumptions of the JDC model and findings of previous studies (Converso et al., 2018, van den Berg et al., 2009, Leijon et al., 2017). The JDC model assumes that low job control can contribute to job strain (Karasek, 1979). However, the JDC model also assumes that it is the combination of job demands and job control, which predicts job strain. Only if job demands were high and at the same time job control was low, high job strain would appear (Karasek, 1979). As we were especially interested in interactions of working conditions with SOC, interactions between job demands and decision authority were not included in the analyses to increase statistical power. Moreover, previous research has only provided modest support for interactive effects of job demands and

control (de Lange et al., 2003). However, if the assumptions of the JDC model were true for our sample, neglecting potential interactions between those dimensions would have led to an underestimation of the effects of decision authority.

Socioemotional selectivity theory states that older individuals have lower goals regarding knowledge acquisition due to reduced future-oriented perspectives (Carstensen et al., 1999). One may therefore assume that skill discretion, which includes development opportunities, are less important for older employees. However, the results within this dissertation rather suggest that skill discretion is related to higher work ability among older employees. This might be interpreted in light of rapidly changing modern work environments, in which lifelong learning is essential to continuously adapt to and stay up to date with technological and digital progress (Smith and Reio, 2006).

5.3 Combined effects of SOC and working conditions

So far, only results concerning direct effects of psychosocial personal factors and working conditions on work ability and telomere length were discussed. However, the first two studies of this dissertation have also investigated interaction effects of SOC and working conditions on either telomere length (Weber et al., 2019b) or work ability (Weber et al., 2018).

Regarding telomere length, an interaction between optimization and learning opportunities was observed. This interaction effect indicates that on the one hand a mismatch between optimization strategies and learning opportunities is related to shorter telomeres. On the other hand, it indicates that especially the combination of high use of optimization strategies and learning opportunities is associated with longer telomeres (Weber et al., 2019b). As described by Weber et al. (2019b), learning new skills or refining existing resources in terms of optimization strategies would have only been possible, if jobs had provided training or learning opportunities. At the same time, learning opportunities would have been especially beneficial, if, according to optimization strategies, efforts were made to develop specifically those resources needed to achieve work goals. A mismatch instead (e.g. low learning opportunities and high use of optimization strategies) implies a lack of person-environment fit, which may result in chronic stress at work (Edwards et al., 1998) and eventually shorter telomeres.

Regarding work ability, an interaction between loss-based selection and decision authority was observed. This interaction effect indicates that loss-based

selection and decision authority will only be positively associated with work ability, if both variables are high (Weber et al., 2018). Similar interaction effects have also been observed by previous cross-sectional research (Weigl et al., 2013, Riedel et al., 2015). On the one hand, work goals would have only been specifically prioritized and selected in terms of loss-based selection, if one had also have the option to decide about one's work goals (Weigl et al., 2013). On the other hand, decision authority would have especially been a valuable job resource, if one had effectively used it to decide on work goals according to loss-based selection (Riedel et al., 2015).

Thus both interaction effects suggest that conducive working conditions are needed to effectively employ SOC strategies and that job resources will especially be valuable for older employees if they apply SOC strategies. The findings support the notion of a dynamic interplay between personal and environmental factors in terms of functioning at work (WHO, 2013) and more specifically in terms of work ability (Ilmarinen, 2001, Ilmarinen and Tuomi, 1992). In the field of organizational psychology, this notion was further developed into a concept called person-environment fit or more specifically person-job fit. The concept of person-job fit states that a subjective mismatch between a person and the job will result in stress and that a perceived fit will result in well-being and work ability (Kooij, 2015, Edwards et al., 1998). A mismatch will on the one hand appear if skills and knowledge do not match with demands at work (demands-abilities fit). On the other hand, it will also appear if a job does not satisfy personal needs (needs-supplies fit; Edwards et al. (1998)). According to Kooij (2015), older employees might on the one hand use SOC strategies to adjust their person-job fit in response to changing resources. On the other hand, one may interpret SOC as needs or abilities, whereas working conditions might be interpreted as demands or supplies. Interpreting our results in this sense indirectly supports the assumptions of the concept of person-job fit, i.e. a mismatch between the person and its job will result in decreased work ability (Kooij, 2015). However, Edwards et al. (1998) argued that direct assessment of person-job fit requires equivalent measures of demands and abilities or needs and supplies. Therefore, testing moderation effects of personal variables on associations between contextual factors and strain are not sufficient (Edwards et al., 1998) and future research is needed to test this hypothesis.

5.4 Strengths and limitations

5.4.1 Sampling and selection bias

A major methodological strength of the second study includes the use of a large randomly selected study sample from the socially insured population in Germany born in 1959 and 1964: the lidA cohort sample. The sample is deemed representative for this study population and belongs to the "baby boom generation", a generation which constitutes an important part of the working population in Germany (Hasselhorn et al., 2014). Prior analyses revealed that the baseline sample drawn in 2011 was very similar to the population of same age being liable to the German social security system in terms of socioeconomic variables (Schröder et al., 2013). However, during follow-up a healthy worker effect cannot be completely excluded due to baseline differences in work ability and working conditions between respondents participating at both waves and dropouts (Weber et al., 2018). Those differences though need careful interpretation as also small effect sizes are statistical significant for such large sample sizes.

A healthy worker effect might have also occurred in the other studies, since study samples only included individuals who are contributing to the labour market. In more detail, individuals with low work ability might have already retired. Those individuals might as well had unfavourable working conditions, strong age stereotypes or low use of SOC strategies and on the same time reacted most strongly to those variables and therefore left the labour market. In this case, a bias towards the null might have emerged. In addition, even a bias across the null (i.e. switch over bias) might have occurred regarding the relationship between SOC and telomere length. If compensation strategies were positively associated with labour participation and telomere length, individuals for whom compensation strategies would have had the strongest effect but not used compensation strategies would not have been participating in the study. Those individuals would have also been more likely to have shorter telomeres. Instead, young and healthy individuals with longer telomeres and who therefore do not need compensation strategies would have remained in the study. Therefore, it might seem that compensation strategies are adversely associated with telomere length.

In study 1, a convenience sample of employees in geriatric care was used. Major advantages of convenience samples include ease and low cost of the sampling procedure (Jager et al., 2017). However, external validity is compromised by this sampling procedure and therefore results need further verification by future research.

Most studies reviewed within the third study have also not used study samples that can be deemed representative to the target population. Furthermore, only 32% of these studies reported response rates above 50%. However, a wide variety of different workplace settings and countries was analysed by these studies with consistent results regarding work engagement, learning, development and promotion intentions as well as intentions to resign and retire (Weber et al., 2019a). It therefore seems likely that the relationship of negative stereotypes towards older workers to those variables is generalizable to other employees outside these study samples. Nevertheless, results regarding an association with self-efficacy, job satisfaction and performance were less conclusive and need further scientific verification.

5.4.2 Temporal sequence of cause and effect

Meta-analyses and systematic reviews of randomized controlled trials are said to attain best evidence for causality (Murad et al., 2016). However, first hypotheses on a topic might be obtained by cross-sectional and longitudinal studies by more convenient and cheaper means. As evidence especially on interactions between working conditions and SOC is lacking, we have opted for cross-sectional and longitudinal study designs. As was acknowledged in study 1, the cross-sectional design however does not inform about the direction of relationships (Weber et al., 2019b). On the one hand, SOC and learning opportunities might really affect the shortening of telomeres. On the other hand, an age-related decline of health and functioning, represented by shorter telomeres, might have led employees to increasingly apply SOC strategies to compensate this loss of resources. The longitudinal design in study 2 gives larger insights about the direction of causality. Even under control of baseline work ability, quantitative demands, decision authority and compensation were associated with future work ability. Furthermore, reverse causation was tested within a subsequent analysis, which revealed that work ability at baseline was not related to most working conditions at follow-up (Weber et al., submitted to Int Arch Occup Environ Health). However, SOC strategies were assessed only once at baseline and therefore the latter analysis could not be made for the relationship between work ability and SOC.

Most studies included in the systematic review used cross-sectional designs to investigate the impact of age stereotypes on older employees (Weber et al., 2019a). It is therefore not possible to rule out reverse causation effects. More specifically, Rothermund and Brandstädter have already noted that age stereotypes might impact views on own ageing as well as views on own ageing might impact the level of age

stereotypes (Rothermund and Brandtstädter, 2003). For example, experience of age-related loss of interest in learning opportunities might have led older employees to agree more to negative stereotypes towards older workers. However, with their experimental study design, Gaillard and Desmette have strengthened the assumption that age stereotypes are a cause for intentions to retire, learn and develop (Gaillard and Desmette, 2010). Moreover, one first longitudinal study found age meta-stereotypes to be significantly related to work engagement within a follow-up period of one year (Kulik et al., 2016). In addition, further evidence for a causal relationship in this direction comes from a number of experimental studies outside the context of work (Lamont et al., 2015).

5.4.3 Reliability and validity of measurement methods

Most variables were measured by self-report of participants. Information on internal consistency reliability (i.e. all items of a scale are interrelated, which increases the probability that they are measuring the same construct (Barry et al., 2013)) and scale validity (i.e. the scale is actually measuring the construct of intent (Barry et al., 2013)) of measures used in study 1 and 2 are given in table 2.

Table 3 Reliability and validity of self-report measures

Variable	Scale	Internal consistency reliability[1]	Validity	References
SOC	Short, modified version of SOC questionnaire	Weak (CA=0.57)	Construct validity	Baltes et al. (1999)
	Short, modified version of SOC questionnaire adapted to work context	Acceptable to good (CA=0.73-0.82)	No information available	Zacher and Frese (2011)
Learning opportunities	TAA-KH-S	Excellent (CA=0.94)	Criterion, content and construct validity	Büssing and Glaser (2002)
Quantitative demands	COPSOQ	Good (CA=0.80)	Criterion, content and construct validity	Nübling et al. (2005)
Decision authority	COPSOQ	Weak (CA=0.66)	Criterion and content validity, moderate construct validity	Nübling et al. (2005)
Skill discretion	COPSOQ	Good (CA=0.81)	Criterion and content validity, moderate construct validity	Nübling et al. (2005)
Work ability	Second dimension of WAI	Acceptable (CA=0.71)	Criterion validity	Hasselhorn and Freude (2007), Tuomi et al. (1999), Ebener et al. (2011)

Notes [1] own calculations except; SOC = selection, optimization and compensation, CA = Cronbach's alpha, TAA-KH-S = Tätigkeits- und Arbeitsanalyseverfahren für das Krankenhaus – Selbstbeobachtungsverfahren, COPSOQ = Copenhagen psychosocial questionnaire, WAI = Work ability index

Only weak reliability was found for the SOC scale used in study 2. A small number of items, dichotomous answer options and the fact that SOC comprises a comprehensive set of behavioural strategies might have reduced Cronbach's alpha (Baltes et al., 1999, Cortina, 1993, Freund and Baltes, 2002). Furthermore, weak

reliability was found for decision authority, a potential reason why only small and partly insignificant relationships to work ability were found. All other variables had at least acceptable reliability.

Either construct or criterion validity was given for most variables. However, I was not able to find information on validity regarding the adapted SOC questionnaire used in study 1. This SOC questionnaire was directly derived from the original validated short form of the SOC questionnaire (Baltes et al., 1999). In this adapted version, the original items for SOC behaviour were expanded by the words “at work” and a five-point rating scale was used instead of dichotomous answer options (Zacher and Frese, 2011). It is therefore highly comparable to the original questionnaire and one might therefore expect similar validity. Reliability and validity of instruments used in selected studies of study 3 are summarized in table 2 by Weber et al (2019a). Especially instruments measuring age meta-stereotypes were appraised as reliable and valid. However, reliability and validity of scales measuring age stereotypes were often questionable as well as measures for outcome assessment (Weber et al., 2019a).

Except for study 1, all analyses exclusively relied on self-report measures. A common method bias might therefore be expected, in which correlations between study variables merely arise through same data collection methods (Spector and Brannick, 2009). However, measuring outcome and predictor at different time points and applying linear regression analyses using a number of independent variables with weak inter-correlations reduces the likelihood of common method bias (Siemsen et al., 2010). Furthermore, interaction effects are rather underestimated in the presence of common method bias (Siemsen et al., 2010). I therefore expect that a common method bias might have only weakly contributed to significant findings and has potentially rather reduced effect sizes of interactions.

Even though leucocyte telomere length (LTL) has been used as an objective marker for biological age and prevents the risk of common method bias, some limitations of its measurement should be acknowledged as described by Weber et al. (2019b). First, high coefficients of variations have been observed for the measurement of mean LTL by quantitative polymerase chain reaction (q-PCR) (Montpetit et al., 2014). Second, intra- and inter-individual variance may occur due to variations in i) proportion, ii) telomere length and iii) telomere attrition rate of different leucocyte sub-populations (Rehkopf et al., 2014, Sanders and Newman, 2013). Third, limited predictive power concerning cognitive functioning, morbidity and

mortality has questioned the use of telomere length as a biomarker of age (Boccardi et al., 2015, Sanders and Newman, 2013). However, an optimized qPCR assay was used reducing variability (Weber et al., 2019b). Moreover, inconsistent evidence questions the benefit of controlling for composition of leucocyte sub-populations in the blood (Rehkopf et al., 2014). In addition, no other marker has been established so far to be a better indicator for biological age (Weber et al., 2019b).

5.5 Implications

5.5.1 Implications for future research

Our results suggest that psychosocial working conditions in terms of job demands, decision authority and skill discretion are associated with work ability of older employees (Weber et al., 2018). Those results are also supported by previous research (van den Berg et al., 2009, Leijon et al., 2017, Converso et al., 2018), which indicates that interventions to improve those psychosocial working conditions might help to support successful ageing at work. Organizational-level interventions to improve psychosocial working conditions have so far only shown moderate effectiveness to increase health and well-being of employees (Montano et al., 2014, Müller, 2016). However, organizational-level interventions creating age-friendly working conditions to promote work ability of older employees are scarce (Weber et al., 2018). More research is therefore needed to explore effective ways to support older employees' work ability.

First interventions to train SOC use have been shown to be effective to improve mental and physical well-being (Becker et al., 2017, Maatouk et al., 2018, Müller et al., 2018, Müller et al., 2016). Even though study results within this dissertation rather point to a minor role of SOC strategies for older employees' work ability, they should, particularly in regard to these prior experimental research findings, not discourage from further research on this topic. However, special attention might be given to potential interactions with working conditions. In more detail, one may investigate whether strengthening the use of SOC might reduce the negative impact of unfavourable working conditions and whether specific working conditions are needed for successful use of SOC.

Even though the influence of age stereotypes on a wide variety of work-related outcomes was tested by previous studies, research on their impact on work performance and self-efficacy is inconclusive and research on work ability is missing. More research is therefore needed in this field. To fill this research gap, we

conducted an international study on country-specific differences of age stereotypes and their association with work ability, but research results still need to be published (AwAKE, study description: Angerer et al. (2017)). Furthermore, longitudinal and experimental research might increase evidence for the causal role of age stereotypes for occupational well-being and retirement intentions. If this research confirmed an underlying role of age stereotypes for work-related outcomes, experimental research could further explore options to reduce negative stereotypes towards older workers and their impact on older employees.

5.5.2 Implications for practice

Results within this dissertation suggest that development and implementation of interventions to improve psychosocial working conditions and to reduce negative stereotypes towards older workers might help to promote work ability of older employees. Regarding psychosocial working conditions, our results indicate that especially the reduction of quantitative demands may enhance the work ability of older employees (Weber et al., 2018). Regarding age stereotypes, it might be useful to inform employers and employees about the incorrectness of common negative age stereotypes and to sensitise about their negative effects for older employees (Weber et al., 2019a). Furthermore, reducing stereotypes of being less interested and able to learn when older might help to increase older employees' motivation to participate in continuing education and increase employers' willingness to provide development opportunities to older employees as well. However, implementation of organizational-level interventions is often impeded due to operational framework conditions or lacking support from employers, managers and employees (Montano et al., 2014, Müller, 2016). In this case, behavioural prevention might complement promotion of favourable working conditions by coaching the use of SOC (Weber et al., 2018). The results within this dissertation suggest that especially enhancement of compensation strategies might be useful to promote the work ability of older employees (Weber et al., 2019b). Furthermore, individual working conditions in terms of decision authority and skill discretion should be considered within such trainings.

5.6 Conclusions

Against the background of current demographic change and the high relevance of psychosocial factors for occupational well-being and work ability, this dissertation aimed to expand previous research on this topic. In doing so, it specifically contributes to occupational health research regarding the role of

psychosocial personal (i.e. SOC, age stereotypes) factors as well as working conditions on an ageing workforce by using a series of different methodological approaches.

The results suggest that SOC and psychosocial working conditions mutually enhance their positive effects in terms of telomere length and older employees' work ability. However, the results also indicate that compensation seems to play the most important role among SOC sub-strategies and that psychosocial working conditions play a greater role for older employees' work ability than the use of SOC. Within the scope of a systematic review, also existing research about the individual consequences of age stereotypes for older workers were gathered. Those studies suggest that own age stereotypes but also expectations regarding age stereotypes held by others might impact older employees regarding self-efficacy, work engagement, job satisfaction and learning, development and retirement intentions.

Hence, those results exemplify that alone and in combination both, psychosocial personal factors and working conditions, need to be considered by future research on the design of an age-friendly work environment.

6 Literature

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