D2.6 - FIRST VERSION OF ELABORATION OF INTERVENTION STRATEGIES

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GLOSSARY

ABBREVIATION	DESCRIPTION
FP	FRAMEWORK PROGRAMME
CSE	Cognitive State Estimation
GPII	Global Public Inclusive Infrastructure
GP	General Physician
WF	Work Functions
WP	Workpackage
HCHSM	Health Care interventions for Health Self-Management
BIPNW	Behavioural Interventions to promote Physical activity, healthy Nutrition and Wellbeing:
BIPNW_PA	_Physical Activity
BIPNW_S	_Sleep
BIPNW_HN	_Healthy Nutrition
BIPNW_WB	_WellBeing
CIMCC	Cognitive function Interventions to Maintain Cognitive Capacity
WMIRS	Work Management Interventions to Reduce work related Stress
WTIAT	Work-related Training Interventions to facilitate knowledge Acquisition and intergenerational knowledge Transfer
WEA	Work Environment Adaptions

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1. Executive Summary

This document is the first version of the deliverable "Elaboration of Intervention strategies" of the SmartWork project. It is intended to specify 'High Level Requirements' to the SmartWork infrastructure and functionality in order to address users' demands as they have been established in WP2 by use cases, derived user needs and illustration of needs as expressed through four personas representing the target group of individual +55-year-old office workers.

In addressing Interventions towards the individual, a transdisciplinary intervention approach is taken by addressing six domains within multi-dimensional aspects of active and healthy ageing. The chapter structure of this document reflects each of those domains:

I Interventions for health self-management;

II behavioural interventions to promote physical activity, healthy nutrition and wellbeing;

III cognitive function interventions to maintain cognitive capacity;

IV work management interventions to reduce work related stress;

V work-related training interventions, to facilitate explicit/implicit knowledge acquisition and intergenerational knowledge transfer; and

VI work environment adaptations.

Within the domains, interventions are motivated and referenced to the user needs, personas, further elaborated and shaped by motivation theories and user values to improve impact, setting goals for behavioural and wellbeing changes to achieve viable results for the individual user.

The concept of intervention in this context is carefully defined by how it comes about – what it is and what causes an intervention. This approach is systematically applied throughout the six intervention chapters and enables further mapping of the interventions onto the envisaged SmartWork services, modules and tools, hence establishing linkage from user needs to the services.

It is important to note that SmartWork does not provide diagnostics, treatment or cure. SmartWork provides advice, guidance and results of changed behaviour to the individual and is meant as a supplement to the users own observations.

The results of the first version of "Elaboration of Intervention strategies", should in this way be a guide to the implementation of the SmartWork elements: The decision support tools, the work

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flexibility tools and training modules, the care management modules and SmartWork services implementation.

It is planned to further refine the intervention strategies through the third year of the project before the planned pilot-trials and finally by the experience achieved through the pilots.

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2. Introduction

This deliverable of Work Package 2: "System Architecture, Requirements and Use Cases", is dedicated to the detailed elaboration of the SmartWork ICT-based intervention strategies. The deliverable title: "Elaboration of Intervention Strategies", is the first version of three planned versions on the subject across the SmartWork project period. A second update is scheduled for M28 prior to the beginning of the pilot-trial and a third update after the end of the pilot-trial in M36.

For the elaboration a transdisciplinary intervention approach is taken, to account for the multi-dimensional aspects of active and healthy ageing:

I interventions for health self-management;

II behavioural interventions to promote physical activity, healthy nutrition and wellbeing;

III cognitive function interventions to maintain cognitive capacity;

IV work management interventions to reduce work related stress;

V work-related training interventions, to facilitate explicit/implicit knowledge acquisition and intergenerational knowledge transfer; and

VI work environment adaptations.

Within the SmartWork context, an **intervention** is defined as any action from the system aiming to promote the wellbeing, health and work productivity of the user in one of the 6 domains above mentioned. An intervention might require, or not, a response from the user. An intervention can be user-triggered, time-triggered, or event-triggered. A *user-triggered* intervention is initiated by the user at any moment in time. A *time-triggered* intervention is scheduled to a certain time of the day, recurrently or not. Finally, an *event-triggered* intervention is generated by the system, for example, as a response to a measurement from the sensing devices.

As mentioned before, the interventions are not intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation and treatment of disease(s). The interventions are intended as a supplement to the user's own observations.

2.1. Structure of this document

After an introduction on the scope of interventions to be elaborated, the background deliverables already carried out and providing a foundation are summarized. The following six sections on

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elaboration intervention strategies are aimed at Self-Management, Work Management, Work Training and Environmental Adaptions.
Section four summarises the relationship with SmartWork services to the level achievable at this first version of the deliverable. Conclusions on the present state on the elaboration are expressed while identifying further work to be done at second version in M28 when more knowledge has been achieved towards the implementation and pilot-tests planned for 2021.

2.2. Relationship to other tasks and deliverables

The relationship of D2.6 to other deliverables of SmartWork are described in the table below:

Deliverable	Relationship
D2.1	This deliverable: State of the Art (SOA) review and benchmarking of best practices, aims to review the existing commercially available solutions and state-of-the art research methodology and approaches on the multi-dimensional aspects relevant for the implementation of the SmartWork system and services.
D2.2	This deliverable: Co-creation methodology, requirements, scenarios and use cases, aims to retrieve what end-users wish and need from an artificial intelligence system. Users are office workers in the age of 55+, employers and/or managers of older office workers and formal or informal caregivers.
D2.3	This deliverable: Data Collection Protocol, aims to establish a preliminary protocol for the data collection phases within the life cycle of the project. The deliverable defines the timing, content, and methods related to the collection of data, and preliminary functionality of the SmartWork system

TABLE 1: RELATIONSHIP TO PRIOR SMARTWORK DELIVERABLES

The results of these deliverables will guide the implementation of the following tasks and WPs.

Tasks/WPs	Relationship
T4.4	Task 4.4: "Personalised predictive models and decision support tools", is grounded on a data-driven approach to identify patterns in heterogeneous data sets of daily living and working, integrating the results of the different sensing technologies and explicit user input (self-reports).
WP6	WP6: Work Flexibility Tools and on-Demand Training", implements the add-on modules for work flexibility functionality, training modules and new skills acquisition.
WP7	WP7: System Integration and SmartWork Services Implementation", integrates technologies and implements the SmartWork services and

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	interventions are based on the architecture and use cases defined in WP2.

TABLE 2 RELATIONSHIP TO SUBSEQUENT SMARTWORK DELIVERABLES

2.2.1. Relations Best Practices

SmartWork deliverable D2.1 Analysis of Current Practices provides a baseline definition and benchmarking of all latest developments and advances in the main technological fields relevant for the implementation of the main technical WPs of the project.

2.2.1.1. Sensing systems for monitoring of physiological and behavioural parameters

A very large variety of devices and services are available on the market as consumer ready devices or as research prototype to monitor various physiological parameters, environmental conditions of indoor home and workspaces, and activity of users during their everyday lives. Currently, physical activity trackers, in addition to monitoring daily steps and distance, are also integrating sensing technologies for heart rate and sleep automatic monitoring and applications for self-reported nutrition information. Taking into account price versus provided functionality and reliability, the FitBit[1] activity trackers are among the best options, as an open API is also provided to integrate with custom applications. The wearable SPARKS ECG devices provides the means to monitor heart function with higher accuracy on the move. In the office environment, the IPN Smart Mouse, provides the means to monitor the office worker during computer work tasks, providing the means to assess work stress and additional physiological parameters (e.g. temperature, galvanic skin response). Sleep quality can be assessed with higher accuracy by using a dedicated sleep mattress sensor, which are place in the bed of the user, with the Withings Sleep Tracking Mat[2] providing the possibility to access its API for third party application integration. For office indoor environment monitoring the SPARKS environmental sensors can be easily integrated in a custom solution to cover the user needs (e.g. grouping sensors to cover an open plan office).

2.2.1.2. Data-driven functional and cognitive modelling of office workers

Handling of the large amount of data generated by the continuous monitoring of users with multiple devices (wearable devices, home devices, work devices) requires at first low-level processing step in order to ensure efficient transmission and storage and prepare them for

[1] https://www.fitbit.com/home

[2] http://developer.withings.com/oauth2/#

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additional meaningful processing. Both, end- and server-side low level processing, are necessary and depending on the problem different methods can be used, including data reduction and imputation methods, and knowledge and feature extraction methods. Encapsulation of the extracted data entities and knowledge into more complex units which provide representations of the human organism functions as a whole or of parts of it (e.g. cognitive capacity) is required to build the virtual user models. The principal components relevant to SmartWork are related to capturing ageing office workers in real conditions, accounting for potential chronic diseases, for their work environment, their lifestyle attitudes, as well as their preferences and needs when it comes to interacting with ICT devices. The most common chronic conditions upon which the viability of people belonging to 55-65 age group is heavily dependent upon are: (1) the cardiovascular system's condition, as heart strain during workers' daily routine is a critical parameter concerning older workers' well-being, (2) the respiratory system condition, as the possible presence of diseases like asthma or Chronic Obstructive Pulmonary Disease (COPD) is much higher; (3) overweight and obesity due to sedentariness especially in the case of office workers; and (4) diabetes, which is a very common chronic condition for the target age group, and it is closely related to overweight and obesity. In addition, frailty is a condition that usually escorts the previously mentioned diseases, thus affecting largely the effectiveness of older people to cope with a chronic condition or fulfilling a work task.

2.2.1.3. Accessible Interaction Interfaces

The accessibility and usability of the ICT systems used in the workplace is a factor of paramount importance to ensure the inclusion of older workers. Approaches such as Universal Design, Universal Usability or Inclusive Design tackle the goal of designing accessible systems while ensuring good usability of the systems. Although the various approaches to universal design or design-for-all are great for developing flexible user interfaces that can be adapted or adjusted to a wider variety of workers and contexts of use, they do not by themselves directly or fully address the need to change the actual interface for different contexts of use --or to adjust and restore the interface on shared computers. The Global Public Inclusive Infrastructure (GPII) provides the needed complementary functionality. Whereas the GPII auto-personalization does not itself provide an interface adaptivity or assistive technology functionality, it does provide automatic personalization of the interfaces for computer software that will be developed and used in the different services developed within SmartWork, specifically the ubiWork Service, aiming at supporting on-the-fly work flexibility through an ubiquitous computer work environment

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2.2.1.4. *Work flexibility tools*

Various task and project management applications and tools are employed in office-based environments to support team collaboration, for example, tools for knowledge management, coordination, information exchange, communication, and shared authoring or co-creation. The analysis performed with respect to integration options, platform availability, task management, and training options shows that Trello[3], Slack[4] and Todoist[5] are among the best options for SmartWork implementation. However, none of these tools do not provide support for semantic description of work tasks, which is necessary to optimize teamwork and pairing activities in the digiTeam service.

2.2.1.5. *Life-long learning and training of older workers*

One of the challenges of keeping older employees up to date and ensuring their continued involvement in the workplace is to provide them with relevant learning opportunities. Continuous learning, either through formal or non-formal means or informally through a variety of means that fosters the continuous practice of cognition, continuous social interaction and continuous physical activity, all of which can encompass an important learning component, is an integral part of active ageing. However, motivation for learning is reduced or at least fragile among older employees. Furthermore, the differences in learning needs and style are extreme in the older workers cohort, being critical to provide on-demand training support and new skills acquisition in order to support the older worker prolong his/her work ability and increase technology acceptance.

2.2.2. Relations to user requirements, scenarios and use cases

SmartWork deliverable 2.2, Co-creation methodology, requirements, scenarios and use cases, aimed to retrieve what end-users wish and need from an artificial intelligence system. Users in this case are office workers in the age of 55+, employers and/or managers of older office workers and formal or informal caregivers. Taking into account that the field trials in this project take place in Portugal and Denmark, the document mainly focused on these two countries.

2.2.2.1. *Office workers, SmartWork Personas*

To make an inventory of office workers' demands and expectations, an online questionnaire in Portuguese and Danish was prepared and distributed among the offices of Cáritas Diocesana de Coimbra and Aarhus Municipality. Next to these questionnaires, an online questionnaire in English

[3] https://trello.com

[4] https://slack.com

[5] https://todoist.com/

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language was available for other older workers from Europe. In the Danish and Portuguese samples 70% females and 30% males participated. 84% of them are not living alone and 32% are informal caregivers. Almost 100% have internet at home. Working at a desk and at a computer (desktop or laptop) are the main activities during the day at the office. They consider as attributes of older workers: experience, beneficial to companies, good mentors and maturity to handle customer service issues. The majority of the workers intends to retire at statutory retirement age.

Regarding the health of the workers 12% report hearing problems and 6% use a hearing aid. 27% of the Danish and 70% of the Portuguese respondents have an eye vision problem. 49% wears glasses. Half of the workers report not to have a chronic disease or condition. Most frequent diseases of the other half are: hypertension, limb using problems, rheumatism, arthritis and diabetes. 93% of them report not to have any difficulties at work due to the chronic disease or condition. 12% of the Danish and 26% of the Portuguese respondents were on sick leave in the last 3 years, mainly less than 5 weeks.

At work Danish employees use laptops and smartphones; Portuguese employees use more desktops and smartphones. Danish workers are almost for 100% familiar with ICT; Portuguese only 64%. Both groups of employees welcome tips and trainings on ICT. This support doesn't have to be invisible. To learn new software, 50% of the employees learn it within 1 hour, 26% learn new software within 2-3 hours and 24% needs more time.

Consulted on their preferences for the SmartWork AI system, they most value as useful or very useful an application that informs on meetings and events, provides guidance, reminds on appointments, provide training contents, transfers work between devices and manages or organises the work. From the European questionnaire most preferable feature would be to have a device that automatically chooses individual settings. Not very useful or not useful at all, Danish and Portuguese employees think are applications that checks the health status every minute, every day or every week. Also, this system should not provide company, report about the working time at the computer or inform the boss on the performances. The SmartWork system should preferably become available on a smartphone or on desktop/laptop. The most preferred interaction should be by keyboard, touch screen, sensor, speech or pictograms.

2.2.2.2. Employers/Managers

Regarding the preferred functionalities of the SmartWork system, Danish employers show quite opposite meanings compared with their Portuguese colleagues. Where Portuguese employers would like to have a system (from most favourite to least) that supports on the fly work practice, identifies training needs, identifies needs for workplace adaptations, supports with optimal employee pairing, reports health and condition of the worker and reports on progress, the majority of Danish employers finds these functionalities not very useful or not useful at all. Only optimal employee pairing, on the fly work practice support and workplace adaptations identification needs are a bit more liked than the rest. The SmartWork system should become available on

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desktop/laptop or on smartphone. Portuguese employers also opt for tablet. Preferred interaction is by keyboard, touch screen and less by pictograms and speech.

2.2.2.3. Caregivers

Most caregivers spend 2-3 hours per day on caring tasks. In majority the caregiving affects the personal life of the caregiver, especially to have less time to go out and to do less daily exercise. However, caregiving also provides a good feeling. Half of the Portuguese caregivers think the caregiving affects their health (10% of the Danish). Especially feeling stressed, tired and sleeping badly are reported as effects. 40% of the Portuguese and 20% of the Danish caregivers report effects on their own working conditions: more remote work at home, absenteeism, less salary and more flexible hours.

Danish caregivers are more positive than employers on eventual SmartWork system functionalities. They most value a system that provides information on health risks and that monitors the health status of the worker they care for. They do not like to have a system that provides personalized care and intervention plans. Portuguese caregivers are positive about every feature (from most to least): monitor of the health status of the worker they care for, personalised care and intervention plans, information on health risks, support in daily planning of care activities and to continuously monitor behavioural attitudes. Preferred devices for the SmartWork system are smartphone and tablet. Preferred interaction: keyboard and touch screen. Danish caregivers additionally would like to have pictograms (icons).

2.2.2.4. Personas/user stories

Based on literature and the consultation of the end-users, the SmartWork consortium developed four personas:

António: Portuguese office worker of 55 years of age. New in the office after a mail delivery function within the organisation of Cáritas. Workplace: shared computer at the office. Suffers from back pain and needs to develop ICT skills. He will use the SmartWork services healthyMe, myWorkability, ubiWork and workCoach.

Luísa: Portuguese caregiver of 26 years of age. She is the daughter of António. She will use the SmartWork service iCare.

Maria: Portuguese manager of 42 years of age. She is new on the job and challenged to improve the productivity of the team. She will use the SmartWork service digiTeam.

Birgit: Danish policy officer of 60 years of age. She herself suffers from diabetes and is caregiver for her husband who has heart problems. She needs work flexibility. Birgit will use the SmartWork services: healthyMe, myWorkability, ubiWork and workCoach.

A day of their lives of the personas has been described in order to define the functional user requirements. Out of these descriptions 12 user stories have been developed to cover 22 identified user needs (see annex) that set the base for the design and development of the SmartWork system

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and services. However, the list of requirements identified by the end-users will be subject of a thorough and careful feasibility analysis by all the technical partners participating in the development of the SmartWork project, for validation or identification of any technical constraints that might appear during implementation. Therefore, it is expected, especially after the technical partners start the development of the SmartWork system, that some of these requirements might be relaxed, refined or removed, in order to avoid any risks of implementing functionalities where their applicability could be limited due to technical constraints. Also, the needs and expectations of the end-users from the SmartWork system is expected to grow throughout the lifetime of the project, especially after the semi-controlled trial and the larger field trials at the offices of Cáritas Diocesana de Coimbra and Aarhus Municipality. These enhancements/refinements providing the final set of requirements, underlying the final SmartWork system functionality and design, will be included in a follow-up of this deliverable, aligning thus the functional specification, design and development of the final SmartWork system.

2.3. Interventions for Work Ability sustainability

Ageing is a gradual process and there is no definition of when someone becomes an "older worker", but many physical changes associated with ageing including decline in vision, hearing and psychomotor coordination are estimated to start as early as the age of 50, especially in the case of women [1]. Furthermore, health chronic conditions prevalence in case of people aged 50+ is very high, with every second person having hypertension and/or some other chronic disease (e.g. high cholesterol, heart disease, mental illness, diabetes, arthritis, back problems, asthma, COPD, etc.) [2], and multimorbidity being very common among people aged 65+ (prevalence rates estimated as high as 65%) [3] . It is worth noting that ill health incapacity is a major cause of labour market exit before the age of 60 [4].

The attractiveness of work for ageing people is a combination of the abilities and attitudes (Work Abilities) of the person together with the design of the work place itself, as established by the Golden Workers Roadmap [5]. The Work Abilities depend on the health status, knowledge and lifelong learning, and motivation. The design of the workplace depends on the type of organization the person is working in and the design of the work functions. The Work Abilities of the ageing workers include physical and mental work capacities, education and competence, and motivation and values. The functional and cognitive work capabilities and motivation, in their turn, are directly linked to the overall health status and well-being of the worker.

The need to prepare for the effect of an ageing workforce has been widely acknowledged by policymakers and researchers. Currently, for over a decade now, the society (e.g. governments, health and insurance systems, etc.) is putting efforts towards finding effective ways to extend working lives and prevent early retirement, thus looking for potential interventions in all life aspects (e.g. work, home) of older people, to support them towards professionally active ageing. A key factor which is likely to influence a worker's capability to continue working is the availability of employment which meets their personal needs and inclinations. Many older workers are more likely

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to carry on working if there is flexibility of working arrangements, such as opportunity to work from home, working part-time and flexible working hour. Furthermore, there is evidence that when appropriately implemented and monitored, flexible work schedules and virtual work programs can positively influence job satisfaction and employee productivity [6].

In this context, a number of national work groups are working on updating and expanding the recommendations targeting at supporting older workers with health conditions stay in and return to work [7], including:

- Integrating specialist support for older workers into occupational health and back to work services
- Encouraging individuals and employers to plan early on for the health changes of working in later life
- Changing attitudes and creating an age friendly working environment.

2.3.1. Physical and mental work capacities

Physical and mental work capacities, both may decline with age. Physical work capacities mainly affect the cardiovascular and musculoskeletal systems, body structure and some important sensory systems, and living habits can accelerate or slow down changes in physiological functioning of ageing individuals. Mental capacity refers to various cognitive and meta-cognitive characteristics of the individuals, such as perception, memory, learning, thinking, the use of language or self-concept, self-value, perceived competency and control of life. The most important changes affecting the Work Abilities are related to weakening of precision and the speed of perception. At the same time, some other mental functions may improve with ageing, including the ability to process complex problems in insecure situations, wisdom, control of life, ability to comprehend the whole, strong commitment to work. Furthermore, exposure to jobs that are mentally demanding are beneficial in increasing levels of cognitive functioning in both young and older workers, with the potential of attenuating age-related cognitive decline over at least a 10-year follow-up [8]. There is also tentative evidence that underscores the importance to implement moderate novelty in work tasks in order to keep the brain active and to counteract age-related decline in functioning [9].

Maintaining an active work life, increased physical activity, intellectual activity and other lifestyle factors have been shown to help reduce the effects of physical and psychological changes [10]. Sensory abilities are subject to change – these are, and can be, catered for in the workplace through the special equipment or workplace adjustments. The correct workplace adjustments support individuals with long term health conditions to stay in work and continue to make a positive contribution. Moreover, there is some evidence that interventions aimed at improving the health and lifestyle of older workers increase physical activity and prevent the onset of chronic diseases [11]. An evidence based review of the health, safety and health promotion needs of older workers [12] identified that although age poses an increased risk of developing a disease, it is not a reason

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to exclude individuals from work. Certain diseases, such as heart diseases or diabetes, can be controlled and reasonable adjustments can be made to keep the individual at work. There is good evidence that supporting workers with chronic conditions to self-manage their health at work can deliver good work outcomes such as job retention or return to work [13], [14].

2.3.2. Knowledge and competences

Education and competence, although not related with ageing per se, is linked to path dependent factors, such as career development trajectories and opportunities as well as non-work factors, such as family conditions, friends and community.

In particular, training and development at the workplace are key aspects for the active ageing of office workers, taking into account the avalanche of new technologies being introduced continuously in their work environment [15]. Having access to training and the possibility for life-long learning (professional competence developed through the use of appropriate learning processes), and at the same time giving older workers the opportunity to pass knowledge on to younger workers, also ensures retention of knowledge within the company. Designing training and instructional programs to promote meaningful learning has been a long-standing challenge, especially for older adults, as they are a very heterogeneous group on a multitude of dimensions including skills and abilities, prior learning experiences, and motivation [16], [17]. Many older adults also experience anxiety in new learning situations or have a lack of confidence about their ability to learn something new. Older adults have much less motivation to engage in new learning, thereby implying the need for different instructional strategies. Furthermore, because of prevailing stereotypes about ageing, older adults are often bypassed with respect to training opportunities or are offered training programs that are not tailored to meet their preferences and needs. Training may take a variety of forms including individual training sessions, group training sessions, workshops, online instruction, an instruction manual, or informal training from a co-worker, family member, friend, or some combination of these [18]. Training programs also vary in duration, frequency, length of training sessions, structure (e.g., passive, interactive), and other factors such as the protocols used for evaluation. Training can also be self-paced or paced by an instructor or a software program and can occur in a variety of settings such as work, at home, in a classroom (e.g., community college), community centre, or some distance-learning location. Preferences of older adults with respect to training format vary according to the topic being studied. However, most older adults prefer training in small groups or learning on their own, they prefer hand-on active learning approaches and learning methods that are easy to access and do not involve large investments of time. The preferences of older adults with respect to training format vary, but most prefer individualized or small group instruction with peers [19].

2.3.3. Motivation and values

Motivation and values are changing as individuals age, as a reorganization in the structure of non-ability traits (such as personality, emotion affect) occurs, giving rise to a qualitatively different

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constellation of motives [20]. Except health, knowledge and skills, older workers are hugely diverse also with respect to aspiration, family duties and financial circumstances, meaning that there are wide variations in the capacity of different individuals to exercise choice overstaying in work. For those who carry on working in older age, work has positively contributed to their self-esteem and identity; they also value friendship and personal relationships with colleagues and are strongly attached to the content and purpose of their work [21]. In addition, some older workers favour certain workplace factors: many are more likely to carry on working if there is flexibility of working arrangements, such as the opportunity to work from home, working part-time and flexible working hours. For example flexible working policies resulted in positive perception of work, home life and personal finances, enhanced self-reported goodwill and increased commitment in the workplace [22].

2.3.4. ICT tools and Work Functions

When examining the future of ICT and ageing at work, the main Work Functions describing the requirements to be analysed for any new ICT-based support tools and interventions, in order to make it appealing also from the employers' point of view, are:

1. ***WF1: Learning and Exercising***. Learning is a central aspect of work, and the ICT skills for office workers are a good example of the importance of learning when knowledge and skills evolve rapidly. The only way to counteract the outdating of knowledge and skills is to integrate education and training in working life [23]. For ageing workers the following dimensions are of major importance: transfer of explicit knowledge for up-to-date valuable knowledge [24]; transfer of tacit knowledge for up-to-date valuable skills [25]; physical exercise to maintain physical abilities [26]; mental exercise to maintain mental abilities [27]. Delivering these various dimensions of learning usually differs across the different types of organizations.
2. ***WF2: Communication***. ICT has the capacity to improve this function for the older workers, and communication plays a key role in teamwork [28]. Communication is fundamental to the other work functions: learning possibilities increase with communication alternatives, collaboration among team members depend on how well they can communicate with each other, worker's productivity depends on having the right information at the right time in the workplace, etc.
3. ***WF3: Coordination***. Depending on the type of organization [29], the coordination challenges are different: large organization may need to use ICT tools to coordinate availability of part time employees who need flexibility at short notice; SMEs may benefit from better coordination technologies for external coordination with partners and customers; mature entrepreneurs may benefit from better external coordination with potential partners and resource suppliers.

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4. ***WF4: Collaboration and Teamwork***. Collaboration and teamwork takes advantage of communication, coordination and control to facilitate combining the knowledge to create new value propositions or deliver products and services to customers [29].
5. ***WF5: Knowledge Management***. When it comes to management of knowledge within an organization, multiple aspects of ICT-based knowledge management must be considered [30]: (i) improved access to ICT-based knowledge repositories facilitates access to expertise that otherwise would be hard to identify; (ii) leveraging knowledge base by well targeted training actions at organization level; (iii) exploiting human resources for informal knowledge transfer.
6. ***WF6: Psycho-physical capacity.*** Psycho-physical capacity (productivity) ICT tools support people to create more in less time, by simplifying access to data, assisting with decision making, simplifying communication or simplifying complex tasks [31]. It depends on the quality of software to automate, simplify and reduce human intervention in organisational processes. Process automation software (ERP, CRM, MRP) are important, technologically advanced, sources of productivity, and better and friendlier human-technology interface positively impact on health at the workplace by reducing the level of stress and job satisfaction. Stress management at work and in the private life has a strong impact on the overall psycho-physical capacity of the worker, especially for job with an increased mental work-load [32].

2.3.5. Interventions for older office workers

Physically inactive and sedentary lifestyles are major public health problems with accumulating evidence that these lifestyles are related to increased risk of developing chronic diseases early in life. In particular, in case of office workers, the prolonged sitting (e.g. spending at least two-thirds of their workday sitting) and overall sedentary life may significantly and independently of other factor increase the risk of cardiometabolic diseases and premature mortality [33], being recommended that people with occupations which are predominantly desk based should progress towards accumulating 2h/day of standing and light activity (light walking) during working hours (e.g. regularly broken up seated-based work with standing-based work, use sit-stand desks, take short active standing breaks) [34], [35]. Office work also affects functional abilities of the workers, with particular risk for the development of musculoskeletal pain [36] and computer-related visual symptoms [37]. Other contextual factors related to the office workspace, including illumination and ambient conditioning system, influence office worker's behaviour, comfort and productivity [38], [39]. Furthermore, there is evidence that high-intensity teleworkers are overall more satisfied than office-based employees and achieve significant benefits from their work arrangement, with work-life conflict most influential towards job satisfaction [40]. Although there is some evidence that job control decreases with age, other factors such as qualifications and job status may also have great impact on the feeling of job security and overall well-being of the older workers.

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3. Interventions

3.1. SmartWork Interventions

The Artificial Intelligence system of SmartWork will unobtrusively and pervasively monitor health, behaviour, cognitive and emotional status of the older worker. Additionally, older workers will be asked regularly to report their findings and wellbeing at work. By doing this, SmartWork is capable to identify and assess the functional and cognitive decline risks that might lead to absence from work or even to early retirement. When certain risks are detected, the SmartWork system subsequently will present possible interventions for the worker to be followed. The interventions will appear on the devices the worker is using, e.g. such as trainings, relax techniques and advises. In this chapter potential interventions are explored and presented, making use of the identified personas and user needs

3.2. Interventions for health self-management

In this section interventions for health self-management are explored and presented. The SmartWork system will only be able to present scores of daily functioning to the office worker; as it is no medical device system, it is not equipped to advise on possible additional steps, such as consulting a GP or therapist.

3.2.1. The self-management domain

Self-management can be defined as the decisions and the behaviour that workers with chronic diseases or impairments engage in that affect their health (and their work). Self-management is important because it helps a person take control of their physical and mental health, reducing health costs and preventing greater issues in the future. Self-management is used in many fields from psychology to medical fields. The rising rate of chronic medical issues makes self-management almost a requirement for people to live healthy lives.

Being able to manage health conditions means that there are less visits to the doctor or that a worker will notice changes in their condition before they become life threatening. Even when applied to mental aspects of health, it is important to note changes in health or when medicine is no longer working. These preventive steps keep health costs low for both the worker and the insurance companies.

In the past decade, in many Western countries the paternalistic approach (the doctor was dominant and made the decisions for the patient) shifted to a shared decision model in which the patient together with the healthcare professional makes decisions [108]. This fits better within the current definition for positive health, which “is the ability to adapt and to self-manage, in the face of social, physical and emotional challenges” [109]. Next to that, it is recognized that lifestyle factors

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influence the development, course and response to treatments and that it is therefore important to give the patient the role of self-manager of his/her own diseases.

The first results on effects of self-management show positive effects on patients, however the sample sizes remain rather low thus far, and the quality of used methodology is not high [110].

The SmartWork system will support the older worker and their employers/managers and caregivers with self-management of occurring health problems or risks, chronic conditions or diseases. Self-management support as an important component of person-centred care has four principles [111]: dignity, coordinated care, personalised care and empowerment. The support on self-management covers the following aspects:

- Commissioning and planning: services embed self-management support and ensure that people have access to support
- Developing knowledge, skills and confidence to better manage the chronic disease or condition for older workers, managers and their carers
- Providing organisational systems and processes that enables support to self-management
- Peer and community support

The interventions of the SmartWork system will follow above mentioned aspects where they are appropriate. The commissioning and planning aspects and peer/community connections are relevant for people with chronic conditions or diseases; however, it is beyond the scope of the SmartWork system. The SmartWork system doesn't assess the quality of support of external health and social care professionals nor provides peer or community support.

3.2.2. Motivations for intervention

Personas references:

After 1 hour of work, António ***has to stretch his back and neck to get rid of the pain. He walks*** *and gets some coffee for himself and his colleagues. The SmartWork system (healthyMe) monitors that he is in pain and checks the way António is sitting and at what height his desk and chair are installed. HealthyMe advises António* ***to request his manager for an adaptable desk and chair****, to achieve that his way of sitting and performing computer tasks improves.*

User scenario Persona 4 Birgit

When she returns at home in the evening, Luísa receives a report from the SmartWork system on the monitoring figures of António's health during the day.

User scenario Persona 2 Luisa

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First thing in the morning at home, Birgit checks her sugar level and if necessary, takes extra measures to level it again. *To avoid that her blood sugar level becomes irregular she will take a rest at the end of the morning.* User scenario Persona 4 Birgit

User needs:

Feature	User Need ID (UN_##)	User Need Description	SmartWork service
Smartphone caregiver	UN_10	App to receive and follow status reports on health and wellbeing	iCare
Adaptable workstation	UN_21	To be able to adjust chairs, desks, monitors at the workstation, adaptable furniture and devices are available	Organisation

3.2.3. Listed and numbered Interventions

TABLE 3 INTERVENTIONS FOR HEALTH SELF-MANAGEMENT

Rationale for intervention			
Group/ID	Name	Description	Rationale
HCHSM_TR1	Training to support self-management	This intervention in the form of online training or coaching will be provided to support the older worker to develop skills, competences to manage his/her own condition or disease	In cases where the worker struggles how to align work and the disease or condition, SW supports by training or coaching provision
HCHSM_TR2	Training to propose organisational and system changes	Providing evidence on workplace improvement and checklists	In cases where working conditions might influence the health and wellbeing of the worker, such as working environment (chair, desk, air) or working equipment (e.g. adaptable for better vision)

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Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
HCHSM_TR1	On indication of the worker him or herself and on indication of the caregiver	Provides links to coaching and self-management tools	- Yes or no use
HCHSM_TR2	On indication of the worker him or herself and on indication of the caregiver	Provides links to information on optimisation of workplace equipment and tools	- Yes or no use

3.2.4. Relationship to SmartWork tools, training modules and services implementation

The intervention self-management is mainly based on reports of the worker him- or herself. The worker indicates that, regarding the chronic disease or condition, additional support in coaching, training or workplace equipment is needed. The short-term trainings and information links will be offered on-demand.

Self-management			
SW Services	**SW Interventions**	**SW Modelling**	**SW Data**
HealthyMe MyWorkability workCoach iCare	Lifestyle User state aware workability prediction Individual training	Lifestyle + activity Functional modelling On Demand training modules	User data Functional data Workability data

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3.3. Behavioural interventions to promote physical activity, sleep, healthy nutrition and wellbeing

In this section and its subsections, we discuss the behavioural interventions in the SmartWork system that promote physical activity, sleep, healthy nutrition and wellbeing. We begin by providing an overview of relevant behaviour change and persuasive technology literature, with a focus on behaviour change theories and tailoring of technology to users' personal situations. In the subsections that follow, we will provide the present guidelines and possible coaching actions (that is, specific interventions) for each of the four domains. We conclude with a table that provides the overview of listed and numbered interventions.

3.3.1. Behaviour change theories

The Social Cognitive Theory is one of the most generally used theories in behavioural interventions. Self-efficacy, one of its constructs, is defined as the belief in one's capability to organize and execute the courses of action required to produce given attainments [41]. If the individual has low self-efficacy, i.e. if s/he does not perceive himself as capable of adopting the new behaviour, it is unlikely that the individual will be motivated to change current behaviour. Therefore, technology-enabled behavioural interventions must ensure the user that s/he has the personal resources necessary to act in the desired manner. To do so, it is important to set not only a long term goal, but also short-term goals that are challenging but achievable, in accordance to the Goal Setting Theory [42]. Several reviews have shown the importance of goal-setting in behavioural interventions promoting, e.g. healthy eating [43], physical activity [44], and supporting self-management of chronic conditions, such as diabetes [45].

The Transtheoretical Model coined by Prochaska and DiClemente in 1983, suggests that a behavioural change process, whether it means recovering from problematic/addictive behaviours or adopting a new healthy behaviour, involves movement through a series of five discrete stages: pre-contemplation, contemplation, preparation, action and maintenance [46]. Each one of these discrete stages is called a *stage-of-change* (Figure 1). In the early stages of this model – pre-contemplation and contemplation – the main strategies consist of creating awareness about the current behaviour (without being aware, there is no perception of any need to change) and educate about the advantages of the desired behaviour. When moving through the several stages, an individual should re-evaluate the goals to keep appropriate goals that are specific, challenging and achievable that continuously adapt to the current behaviour of the individual [42]. Setting goals that are too difficult for the user to achieve can lead to frustration and drop-out. Commitment to take actions is also very important, as considered in the strategy of implementation intentions, which states that an individual is more likely to take an action if s/he has previously committed to perform that action [47].

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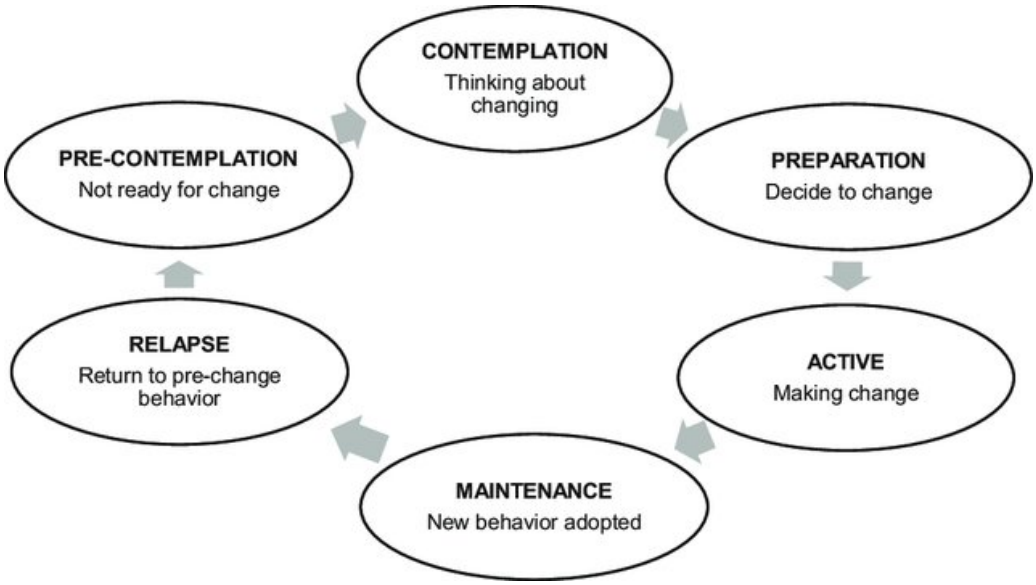

FIGURE 1 - TRANSTHEORETICAL MODEL AND STAGES OF CHANGE.

It is also necessary to take into consideration the reasons why an individual takes an action. The Self-Determination Theory defines three types of motivation: extrinsic motivation, intrinsic motivation, and a-motivation. Extrinsic and intrinsic motivation both represent a state in which motivation is present in people. A-motivation on the other hand is a state in which "people either do not act at all or act without intent – they just go through the motions". While extrinsic motivation refers to "the performance of an activity in order to attain some separable outcome" (think of monetary reward), the intrinsic motivation "refers to doing an activity for the inherent satisfaction of the activity itself" [48, p. 71]. Experiencing pleasure or enjoyment while performing an action, is a motivator to repeat that action. Translating this to behavioural interventions, by learning what the user enjoys doing and adapting the coaching strategy accordingly, we are likely to increase the adherence to the interventions as the individual is more likely to comply with the advice. The Self-Determination Theory is not the only theory referring to the driven effect of positive emotions in behavioural interventions. Building upon the Broaden-and-Build Theory, which states that positive emotions broaden individuals' momentary thought-action responses and support in building a variety of resilience resources [49], Frederickson has introduced the 'upward spiral theory of lifestyle changes' [50]. According to this offshoot of the Broaden-and-Build Theory, individuals experiencing positive emotions are more likely to be open to new activities, and consequently initialize, new behaviours; these new activities, and behaviours support building of personal resources which enhance health and feelings of fulfilment and accomplishment for adopting the healthy behaviours, producing experiences of positive emotions, and creating an upward spiral. Furthermore, incorporating Berridge's perspectives on a difference between liking (i.e. the same concept of pleasure as used in the Self-Determination Theory) and wanting (similar to a drug addict that 'wants' to take a drug even when he does not experience pleasure with that action anymore) [51], [52], Frederickson suggests that there is an inner layer of the spiral, in which positive emotions, including those that go beyond pleasure, can be non-conscious motivators for

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sustainable decisions to maintain healthy lifestyles. A systematic review on the relation between positive emotions and independence in performing activities of daily living among older adults, supported this bi-directional relation with longitudinal studies suggesting that those with higher levels of positive emotions at baseline were more likely to have better functioning at follow-up [53]. An hypothesis is given by Cooper and colleagues, who suggest that when older adults are faced with a decline in functioning, those with higher levels of positive characteristics are likely better at building a variety of personal, social and environmental resources to counteract that decline and keep their independence [54]. Building resilience resources is particularly relevant in the older populations, as with age, people are more likely to encounter adversity on the health domain (e.g. functional decline) and in terms of life-changing events (e.g. death of relative).

Unobtrusive technology facilitates learning what individuals do and experience in daily life and apply the behaviour change theories mentioned above. A meta-analysis from Fanning and colleagues shows that indeed technology-based interventions targeting promotion of physical activity are more effective when relying on behaviour models [55]. New behavioural models are also being designed with technology-enabled interventions in mind. One example is Fogg's Behaviour Model (Figure 2) which suggests that new behaviours result from a combination of motivation, ability and triggers [56]. This means that an individual must be motivated and have the skills (ability) to perform a new behaviour. The trigger given by the behaviour change system must meet the motivation and ability of the individual at any given moment. Fogg defines three types of triggers: spark (when a person lacks motivation), facilitator (when a person is motivated but lacks ability) and signal (as a simple reminder when a person is highly motivated and has high ability). Even those who are intrinsically motivated to adopt a certain behaviour, experience ups and downs in their motivation. Triggers in the path of the individual remind and highlight why the change in behaviour is desired and, for example, why this is a good moment to take an action. This work resulted in Fogg's "Behaviour Grid" which specifies 15 types of behaviour, in a 3x5 matrix, where the first dimension concerns the duration of the intended behaviours (one time event, specific duration event, or permanent change) and the other dimension concerns, what the authors call, "Flavour" (new vs. familiar behaviour, encourage vs. discourage vs. stop behaviour) [57].

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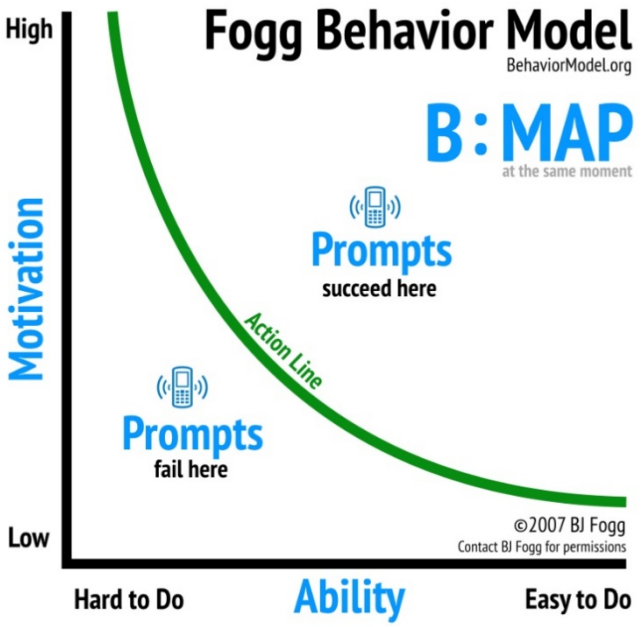

FIGURE 2 - GRAPHICAL REPRESENTATION OF FOGG'S BEHAVIOUR MODEL.

3.3.1.1. Personalization of digital health interventions

Each individual is unique, and dynamic, in a sense that a strategy that works for one, might not work for another, and even what previously motivated an individual in the beginning of the intervention might not motivate the same individual at a later point in time. Persuasive technology can benefit from what is nowadays called personalized health: each person has an individually 'tailored' plan, like a tailor fitting a suit. This means that we can tailor the interventions and the communication to the user. Since each individual is different, it is widely believed that tailoring, or personalization, helps increasing the adherence, and effectiveness, of technology promoting behaviour change [58]. Hawkins et al. defined tailoring as "any of a number of methods for creating communications individualized for their receivers, with the expectation that this individualization will lead to larger intended effects of these communications" [59]. Technology developers must not forget to put the user in control, whenever the physical and cognitive capabilities allow it [60]. An outcome of all our user studies was that, users do want to feel in control of the technology, and not the other way around. This means, that technology should support the user, but should not replace functions, with the fear that it will lead to underuse [61].

Tailoring of a technological intervention can be performed on many aspects of a person's profile. One of these aspects is someone's type of motivation. A recent study found that older adults' preference for persuasive features is linked to their type of motivation for living healthily [62]. The type of motivation was determined by asking participants to indicate their agreement (on a seven-point Likert scale) with 11 statements. An example of such a statement would be "I live healthily,

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because I think others would disapprove of me if I didn't.", for which a high score would correspond to a person that is motivated by external factors. Examples of persuasive features that are appreciated by people who were motivated from within are 'self goal setting' and 'health education', and for externally motivated people examples include 'showing progress' and 'social competition'. People with the a-motivation motivation type did not appreciated any features.

As a basis for the tailoring that is performed, within WP4, general population models will be built based on large available datasets. Over time, with the data collected from the sensing platform and direct input from the user, the applied coaching strategies can be adapted to the user based on their personal models. These coaching strategies will guide the specific coaching actions that are taken for each person. For example, when applying a coaching strategy with a strong focus on the health education component, the participant might be provided with information on why they should be physically active. A coaching strategy that puts more weight on showing progress, might give more weight to performing coaching actions that provide the user insight in their recent behaviour as compared to a previous moment in time, while being less related to providing the user with information on 'why' living healthily is good for them.

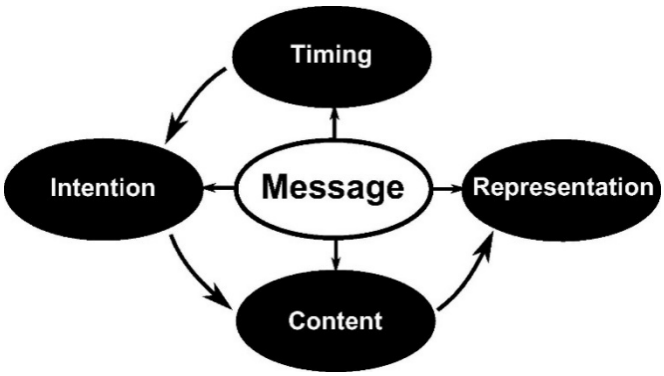

FIGURE 3: THE HIGH LEVEL MODEL OF TAILORING (FOR MOTIVATIONAL MESSAGES) [63].

Once the intent of a message is clear, and the tailored content is decided, the final step in tailoring the interaction to the user is the chosen representation. This process follows the same steps as to the *intent*, *event*, and *strategy* elements in the 'analyzing the persuasion context' step of the Persuasive Systems Design model [64]. Examples of representations are motivational messages (see Figure 3 for a model for the full high-level tailoring process of motivational messages), embodied conversational agents, or even the growing flower on the Fitbit watch face (Figure 4).

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FIGURE 4: FITBIT WATCH FACE SHOWING A FLOWER THAT GROWS WHEN ACTIVITY INCREASES AND WILTS WHEN ACTIVITY DECREASES [6].

3.3.2. Behavioural interventions from user stories in D2.2

In this sub-section we provide excerpts of the user scenarios provided in Deliverable 2.2., concerning the behavioural interventions within the SmartWork system.

> *"After 1 hour of work, **António has to stretch his back and neck** to get rid of the pain. He walks and gets some coffee for himself and his colleagues. The SmartWork system (healthyMe) **monitors that he is in pain** and checks the way António is sitting and at what height his desk and chair are installed.*
>
> *[…]*

> *"Birgit takes her rest from 11.30-13.00 hours. After lunch she **puts on her bracelet** with healthyMe, and cycles to the office."*
>
> *[…]*
>
> *myWorkAbility reports that **she did well today** to cycle and by adjusting the chair and desk and that she had **more stress** when she was struggling with answering some questions. Her stress level was well again when she was able to talk with some colleagues from her team."*

[6] Images taken from the Fitbit community webpage at Fitbit.com.

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Based on these user stories, the following User Needs were defined also within D2.2:

- UN_6: To monitor the stress level, alerts when it is too high and delivers advices
- UN_7: To monitor the daily food consumption. Advise on quantity, quality and health.
- UN_8: To monitor the distances of walking, gymnastics and other physical activity and to advise.

> *"She checks if there are any **irregularities** compared to other days"*
> User scenario Persona 2 Luísa

Although these user needs provide a good starting point for the discussion of the behavioural interventions, a more in-depth analysis should be performed in order to elicit requirements that captures the holistic perspective of the healthyMe service of SmartWork.

3.3.3. Physical activity

3.3.3.1. Physical activity guidelines

A physically active lifestyle is crucial for prevention of chronic illnesses and for the general health and well-being of the individual. The World Health Organization (WHO) establishes a set of recommendations on physical activity for population aged 18-64 years old [65]:

- **Daily Physical Activity:** physical activity achieved while performing activities of daily living as transportation (e.g. walking or cycling), occupational, household tasks, play, games or planned exercise, in the context of daily, family and community activities.
- **Physical fitness:**
  - At least 150 minutes of moderate-intensity aerobic physical activity throughout the week OR do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week OR an equivalent combination of moderate- and vigorous-intensity activity;
  - Aerobic activity should be performed in bouts of at least 10 minutes duration;
  - For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week OR engage in 150 minutes of vigorous-intensity aerobic physical activity per week, OR an equivalent combination of moderate- and vigorous-intensity activity.
  - Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week.

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As also stated in the global recommendations, and in line with the behavioural change theories stated above, inactive people should start with small amounts of physical activity and gradually increase duration, frequency and intensity over time.

Since the WHO guidelines were released in 2011, there is been an ongoing discussion among the research community about the need for "10 minutes bouts". For example, the 2nd Edition of the "Physical Activity Guidelines for Americans" has dropped out this requirement, under the mote that "some physical activity is better than none" [66].

3.3.3.2. Behavioural interventions to promote physical activity

In a qualitative study developed in the context of the European project PERSSILAA (FP7-ICT-610359))[7], an, we interview with 12 older adults is carried out to investigate attitudes and wishes towards the use of mobile technology to support health management in daily life [60]. When asked about wishes from technology to support being physically active, the participants were mostly interested in feedback on their progress compared to previous activities (e.g. "how active am I today compared to yesterday?") or compared to peers (e.g. "Am I active enough compared to people from my age?"). Therefore, in the SmartWork system, providing *feedback* is in the core of the behavioural interventions to promote physical activity. Based on the behaviour change theories provided in section 3.3.1, we provide a list of potential interventions, a.k.a. coaching actions, aimed to support the user reaching an active lifestyle:

- **Self-assessment at baseline:** This strategy aims to guide the user reflecting on the questions *what is my current activity level?* and *what motivates me?* The self-assessment at baseline allows the system creating a psychological profile of the user regarding physical activity, for example, by assessing self-efficacy and the type of motivation of the user.
- **Identify user preferences:** Builds the personal physical activity profile, which in turn allows other actions to be personalised. Examples of preferences could be to identify pleasurable activities, which context is preferred (indoors vs. outdoors), the attitude towards social companion (alone vs. with someone else), or the intensity of activity (light vs. moderate vs. vigorous activity).
- **Set a long-term goal**: A long-term physical activity goal is set in collaboration with the user based on global guidelines for physical activity, or therapeutic goals which considering the medical history of the user. The aim is to reflect on the question *Where do I want to go?*
- **Set a short-term goal:** Looking at physical activity promotion, personalized goals are particularly relevant in the older population due to the heterogeneity of this group, as it is

[7] https://perssilaa.com/

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likely that older adults experience some degree of disability [67], [68]. Therefore, a daily physical activity goal should be set according to the current behaviour of the individual. A personalized goal can be set automatically by the system based on previous behaviour (e.g. [69]), or can be decided by the user, satisfying a need for control.

- **Discuss a goal: T**his action serves a dual purpose. Its first function is that it satisfies a need for control. Older adults want to feel in control when using technology to support in the self-management of their health [60]. The second function is that it allows for a goal to be changed when it turns out that it is no longer suitable, for example, because it is too low or because there are life changes that influence the type of activities that a user can easily perform.
- **Schedule activities:** The user can commit to perform an activity by scheduling for a later moment in the day or week (e.g. go for a walk).
- **Provide feedback:** Feedback on the user's physical activity behaviour is given based on data collected via the unobtrusive sensing platform (WP3).
- **Inform "how":** Suggest an activity, and possibly a time or location. Depending on the preferences of the user (see *Identify user preferences*), a few examples can be given as options, or the most suitable option can be explained.
- **Reminders:** Remind the user that they had planned to do an activity (see *Schedule activities*) or to be active to break a longer period of inactivity (e.g., do some exercises, or take a short walk).
- **Office-friendly exercises**: At opportune moments, the SmartWork system suggests office-friendly physical exercises focusing on stretching the muscles.
- **Rewards**: The user is given virtual rewards when achieving the physical activity goals set in the SmartWork system. These gamified elements are likely to encourage users to achieve his/her goals.
- **Challenges:** The user can set his/her own 3-day challenges (e.g. "In the upcoming 3 days I to reach 12.000 steps."). The user will receive a virtual reward for each one of the days achieving the goal. This gamified feature is aimed at increasing extrinsic motivation and might even be used as team-challenge in future versions of SmartWork.

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LISTED AND NUMBERED INTERVENTIONS

TABLE 4 INTERVENTIONS FOR PHYSICAL ACTIVITY

Rationale for intervention			
Group/ID	**Name**	**Description**	**Rationale**
BIPNW_PA_TR1	Self-assessment at baseline	Set of questionnaires presented at baseline for assessing current practices, goals and attitude related to physical activity.	Induce self-reflection and identify motivational profile of the user
BIPNW_PA_TR2	Set a long-term goal	The system, together with the user, set the long-term physical activity goal. This goal can be operationalized in terms of steps, minutes of activity, or minutes of inactivity.	Goal-Setting Theory
BIPNW_PA_TR3	Set a short-term goal	The system, together with the user, sets the short-term physical activity goal.	Goal-Setting Theory, Social Cognitive Theory
BIPNW_PA_TR4	Discuss a goal	When the user rejects a suggestion for a goal, the system makes a new suggestion until an agreement is reached.	Goal-Setting Theory Need for control
BIPNW_PA_TR5	Identify user preferences	Set of questions to identify the user's preference regarding physical activity.	Tailoring of the motivational strategy to increase motivation, adherence and compliance to intervention
BIPNW_PA_TR6	Schedule activities/Make a plan	The system allows the user to schedule moments to dedicate to be physically active, if possible, in combination with the work agenda of the user.	Implementation Intentions

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BIPNW_PA_TR7	Provide feedback	The system provides feedback on the current physical (in)activity of the user, for example, in comparison to the daily goal.	Social Cognitive Theory

Rationale for intervention – cont.			
Group/ID	**Name**	**Description**	**Rationale**
BIPNW_PA_TR8	Inform "how", suggest activity	The system provides suggestions on how to be more physically active matching the user profile (BIPNW_PA_TR5).	Self-Determination Theory Broaden-and-Build Theory
BIPNW_PA_TR9	Reminders	The system will remind the user of the time of the scheduled activities (BIPNW_PA_TR6). The system will also remind that it is time to move after a period of inactivity longer than 1 hour.	Increase likelihood that the user will commit to the planned activities. Break periods of prolonged inactivity.
BIPNW_PA_TR10	Office-friendly exercises	The system will provide a short set of office-friendly exercises to stretch the muscles.	Remind and support the user having short breaks during the day and use that time to stretch the muscles.
BIPNW_PA_TR11	Rewards	The system provides virtual rewards when a milestone is met.	Self-Determination Theory
BIPNW_PA_TR12	Challenges	The system allows to set individual or group challenges to foster extrinsic motivation to be physically active.	Self-Determination Theory

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Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
BIPNW_PA_TR1	Event-triggered at the baseline	Provide a set of questions to the user in form of questionnaires or via a conversational agent. Store the relevant parameters for the user model.	Answer the questions provided by the system
BIPNW_PA_TR2	Event-triggered at the baseline; user-triggered	Provide a suggestion for a long-term goal based on the current guidelines for physical activity	Agree or disagree with the goal proposed.

Technical specification – cont.			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
BIPNW_PA_TR3	Event-triggered at the baseline and time-triggered (once a week)	Provide a suggestion for a short-term goal based on the current physical activity level gathered in the self-assessment (BIPNW_TR1) or based on the measurements from the fitness sensor in the previous week.	Agree or disagree with the goal proposed.
BIPNW_PA_TR4	Event-triggered in case the user disagrees with the suggest goal in BIPNW_TR2 and BIPNW_TR3	Provide a new suggestion for the (long or short-term) goal until the user agrees.	Agree or disagree with the goal proposed.
BIPNW_PA_TR5	Event-triggered at the baseline	Provide a set of questions to the user in form of questionnaires or via a conversational agent.	Answer the questions provided by the system

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		Store the relevant parameters for the user model.	
BIPNW_PA_TR6	Event-triggered or User-triggered	Provide a suggestion for an activity that matches the user profile, duration and a timeslot, if possible, compatible with the work agenda of the user. Store the type of activity, duration and timeslot.	If disagree with the suggestion, make change in the duration or timeslot and save.
BIPNW_PA_TR7	Event-triggered or User-triggered	Continuously inform the user about physical activity progress in real-time. Inform the user when reaching a goal.	NA

Technical specification – cont.			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
BIPNW_PA_TR8	Time-triggered (Tt) or User-triggered (Ut)	Provide a message to the user with relevant information on how to reach an active lifestyle (Tt). The user asks for a suggestion (Ut).	Acknowledge reading the message.
BIPNW_PA_TR9	Time-triggered (Tt) or Event-triggered (Et)	Inform the user that it is almost time for a planned activity (Tt). Inform the user if he/she has done less than 200 steps in the last hour.	Acknowledge reading the message.
BIPNW_PA_TR10	Time-triggered (Tt) or Event-triggered (Et)	Provide a set of sequential videos of office-friendly exercises.	Acknowledge going through the exercises.
BIPNW_PA_TR11	Event-triggered	Provide and store a virtual reward every time	NA.

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		the user reaches a milestone.	
BIPNW_PA_TR12	Time-triggered	Once a week provide a suggestion for a 3-day challenge from the list of challenges available for physical activity.	Accept or reject the challenge.

3.3.4. Sleep

3.3.4.1. Sleep guidelines

According to the report from RAND Europe, insufficient sleep alone costs around 2.3% of the GDP in the United Stated of America and 1.6% of the GDP in Germany [70]. The same study suggests that slightly increasing the sleep time (from 6 to between 6 and 7 hours) would already have a significant impact on the economy of these countries. Looking at the work context in particular, it is estimated that sleep deprivation leads to a loss of 200.000 working days on an annual basis in Germany. Sleep disruption has consequences on the short- (e.g. stress and psychological issues) and long-term (e.g. cardiovascular disease, obesity and type 2 diabetes) [71]. For example, a sleep duration shorter than 4.5 hours was found to be associated with obesity [72]. Sleep-related disorders are particularly relevant for chronic populations, as for example, treatment of obstructive sleep apnoea syndrome in patients with diabetes might lower 24-h blood pressure [73]. Ancoli-Israel suggests that 57% of older adults (>=65 years old) report some degree of sleep-related complaint [74].

We spend a considerable portion of our 24-hour day asleep. That means that when considering the promotion of healthy lifestyles, and physical activity in particular, one should keep in mind that motivating time engaged in a physical activity intensity (e.g. Moderate-to-Vigorous physical activity), will come at the expense of less time in another behaviour. This can be the case of people who wake up early for exercise, reducing their sleep time. A new line of research, so called, Compositional Analysis of Physical Activity, is now looking at physical activity as part of a pattern over 24-hour period, including: sleep time, sedentary time and light, moderate- or vigorous-intensity physical activity [75]–[77]. Following this line, sleep is being included in the most recent guidelines for physical activity, as being part of a 24-hour period of activity. This means that the study of physical activity can no longer be dissociated from the evaluation of sleep, as to meet the physical activity time recommendations. In the beginning of 2019, the World Health Organization launched the *Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age* [78] and it is expected that in the near future similar guidelines will be made available for the other age groups. The Canadian Society for Exercise Physiology has also incorporate sleep guidelines in its official *Canadian 24-hour movement guidelines: An Integration of Physical Activity,*

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Sedentary behaviour and Sleep, currently only among children and youth, but soon to be also available for other age groups [79].

All-in-all, maintaining a healthy lifestyle in terms of physical activity and healthy eating is also known to be beneficial for sleep health as a secondary outcome. In this sense, the promotion of a good sleep hygiene is intertwined with the promotion of physical activity and healthy nutrition.

3.3.4.2. Behavioural interventions to promote sleep hygiene

In a systematic review, Grigsby-Toussaint and colleagues identified *realistic goal-setting* (86%), *time management* (77%) and *self-monitoring* (66%) as the most used behavioural interventions in smartphone applications aiming to support management of sleep [80]. When looking at persuasive technology components, 54% of the apps provided *positive feedback* and 40% incorporated *social praise* to improve motivation. However, the effectiveness of such apps as not yet been reviewed.

Within SmartWork, the interventions to promote sleep hygiene will mainly focus on providing the tools for self-reflection and education to support the older office worker reach a restful night of sleep.

- **Self-assessment at baseline**: Encourage self-reflection about sleep related routines by providing a questionnaire to the user;
- **Inform "how"**: Inform about strategies to improve sleep hygiene. List of examples:
    - Reduce intensity of the light one hour before the desired sleep time;
    - Avoid heavy meals two hours before going to sleep;
    - Limit the time in bed to a maximum of 8 hours;
    - Aim to go to bed approximately at the same time every night. In the weekends do not deviate more than 1.5 hours of your regular go to bedtime;
    - Stay in bed only to sleep. Go to bed only when you feel tired and get out of bed if you do not manage to fall asleep;
    - Limit the time reading or watching-TV in bed to 30 minutes and make sure that what you read/watch is not too exciting;
    - Make sure you have warm feet when going to sleep;
    - A warm batch 2.5 hours before bedtime can help with falling asleep;
    - Do not take naps in the evening and limit your daily naps to a maximum of 30 minutes;
    - Avoid caffeine after 6 pm (e.g. coffee, black tea, coca-cola and chocolate);
    - Being physically active helps regulating the sleeping pattern;
    - Plan 2 moments of rest from 5 to 10 minutes every day.

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- **Set preferred sleep time**: The user sets his/her preferred sleep time and how far in advance would like to be reminded. At the given time;
- **Reminders:** If a preferred sleep time is selected, the SmartWork system provides a gentle reminder that it is time to initiate sleep routine 30 minutes before the pre-defined time;
- **Context-dependent information**: While at the office, the user can be reminded to keep the blinds open and if possible go for a walk outside, as this is known for improving sleep [81];
- **Challenges**: The user can set his/her own 3-day challenges (e.g. "In the upcoming 3 days I want to go to sleep before 22h."). The user will be virtually rewarded when the challenge is achieved.

LISTED AND NUMBERED INTERVENTIONS

TABLE 5 INTERVENTIONS FOR SLEEP

Rationale for intervention			
Group/ID	**Name**	**Description**	**Rationale**
BIPNW_S_IN1	Self-assessment at baseline	Set of questionnaires presented at baseline to encourage self-awareness on sleeping habits.	Induce self-reflection
BIPNW_S_IN2	Inform "how"	The system shows suggestions to the user on how to improve sleep quality	Self-Determination Theory
BIPNW_S_IN3	Set preferred sleep time	The system allows the user to select a preferred sleep time.	Goal-setting Theory; Implementation Intentions
BIPNW_S_IN4	Reminder	The system reminds the user 30 minutes before the defined preferred sleep time (BIPNW_S_IN3)	Increase likelihood that the user will commit to the preferred sleep time.
BIPNW_S_IN5	Context-dependent information	The system provides context-dependent advice based on the location of the user.	Increase likelihood that the user will act upon the advice provided.

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BIPNW_S_IN6	Challenges	The system allows to set individual challenges to foster extrinsic motivation to follow the advices (BIPNW_S_IN2).	Self-determination Theory

Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
BIPNW_S_TR1	Time-triggered	Provide a set of questions to the user in form of questionnaires or via a conversational agent. Store the relevant parameters for the user model.	Answer the questions provided.

Technical specification – cont.			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
BIPNW_S_TR2	Time-triggered (Tt) or User-triggered (Ut)	Provide a message to the user with relevant information on how to improve sleep quality (Tt). The user asks for a suggestion (Ut).	Acknowledge receiving the advice.
BIPNW_S_TR3	Event-triggered (Et) or User-triggered (Ut)	At baseline (Et) or upon user request (Ut), provide a suggestion for a sleep time.	Agree or adjust the suggested time.
BIPNW_S_TR4	Reminder	Provide a reminder of the preferred sleep-time daily, 30 minutes before the pre-defined time.	Acknowledge receiving the reminder.
BIPNW_S_TR5	Event-triggered	Provide context-dependent advice based	Acknowledge receiving the advice.

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		on the location of the user. At home, provide advice related to the home environment and at work provide advice related to the office environment.	
BIPNW_S_TR6	Time-triggered	Once a week provide a suggestion for a 3-day challenge from the list of challenges available to improve sleep hygiene.	Accept or reject challenge.

3.3.5. Healthy Nutrition

In 2015, the World Health Organization released the 'European Food and Nutrition Action Plan 2015-2020' [82]. The intention for this action plan is to reduce the burden of preventable diet-related noncommunicable diseases, obesity and all other forms of malnutrition still prevalent in the WHO European Region. The plan mentions excess body weight (body mass index > 25kg/m2), excessive consumption of energy, saturated fats, trans-fats, sugar and salt, and low consumption of vegetables, fruits and whole grains as the leading risk factors and priority concerns. In addition, some countries are at the same time also challenged by nutrient deficiencies [82].

3.3.5.1. Nutrition guidelines

The WHO defines the types of food for which consumption should be limited to sustain a healthy diet (that is, energy-dense, micronutrient-poor foods and non-alcoholic beverages) as *food products high in energy, saturated fats, trans-fats, sugar or salt*. Three key aspects that the WHO lists to take action on [83] are the following:

- *Energy intake (calories)* and energy expenditure should be balanced. Energy intake should not consist of more than 30% fat – of this percentage, a maximum of 1/3 can be saturated fats, and no more of 1% of total energy intake should be trans-fats. A shift from saturated fats and trans-fats to unsaturated fats is also recommended. Ultimately, the goal is to eliminate industrially produced trans-fats.
- The intake of *free sugars* should be limited to less than 10% of total energy intake. For additional benefits it is suggested to reducing this to less than 5%.
- *Salt intake* should be no more than 5 grams per day (this equals 2 grams of sodium).

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The details of what constitutes a healthy diet vary per person and these are heavily influenced by many factors, such as age, gender, but also cultural context, locally available foods and dietary customs (World Health Organization, 2018). With these notions in mind, we will discuss the nutritional challenges and guidelines for the Danish and Portuguese populations separately.

NUTRITION GUIDELINES FOR DENMARK

While Denmark is on track to meeting targets with regards to Diabetes (both for males, 5.4%, and females, 3.3%), areas that are not on track are anaemia for women of reproductive age (16.3%), low birth weight (5.3%, constant since 2014), and male and female obesity (22.3% and 17%, respectively) [84]. Denmark's national plan incorporates targets for obesity in children, adolescents and adults.

National policies in Denmark regarding nutrition include mandatory legislation for salt iodisation, policies to limit saturated fatty acids and virtually eliminate industrially produced trans-fats, NCD and diabetes policies, policies to reduce impact of food marketing on children (with regards to fats, sugars, and salt), and food-based dietary guidelines. Denmark does not have a sugar-sweetened beverage tax. [84]

Dietary recommendations for the Danish follow the Danish food-based dietary guidelines (FBDG) [85]. These guidelines are:

- Eat a variety of foods, but not too much, and be physically active
- Eat fruits and many vegetables (600 grams per day, of which at least half vegetables)
- Eat more fish (350 grams a week of which 200 grams fatty fish)
- Choose whole grains (eat 75 grams per day).
- Choose lean meats and lean cold meats (500 grams per week, for 2-3 meals)
- Choose low fat dairy products (e.g. less than 0.7% fat for products such as yoghurt and 17% or 30+ for cheese)
- Eat less saturated fat
- Eat foods with less salt
- Eat less sugar (e.g. drink max 0.5 litres of soda per week)
- Drink water

These Danish guidelines are based on the 2012 version of the Nordic Nutrition Recommendations (NNR) [86].

NUTRITION GUIDELINES FOR PORTUGAL

While Portugal is on track to meeting targets with regards to female Diabetes (5.3% of women), areas that are not on track and still require attention are anaemia in women of reproductive age (for 17.5% of women), low birth weight (a slight increase from 8.8% in 2014 to 8.9%), male diabetes

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(8.4% of men), and male and female obesity (20.3% and 21.2%, respectively) [87]. Portugal's national plan incorporates targets for overweight adults and adolescents.

National policies in Portugal regarding nutrition include a sugar sweetened beverage tax, NCD and diabetes policies, policies to reduce impact of food marketing on children (with regards to fats, sugars, and salt), and food-based dietary guidelines. Portugal does not have mandatory legislation for salt iodisation and does not have a policy to limit saturated fatty acids and eliminate industrially produced trans-fats [87].

Davis et al. wrote a review paper defining what elements make up the Mediterranean Diet [88]. The diet as they define it consists of the following (in grams/day):

- Bread (300 grams)
- All cereals (including bread) (305 grams)
- Legumes (35 grams)
- Potato (125 grams)
- All vegetables (including potatoes) (375 grams)
- Fruits (225 grams)
- Nuts (4 grams)
- Meat/meat products (105 grams)
- Cheese (21 grams)
- Other dairy (215 grams)
- Eggs (23 grams)
- Olive oil (45 grams)
- Fish (50 grams)

COMPARISON BETWEEN DENMARK AND PORTUGAL ON CURRENT DIET

Figure 5 and Figure 6 provide an insight into the consumption of food groups and components for Denmark and Portugal in 2016. The TMREL values indicated define the safe minimum or maximum daily intake of a food group or nutrient.

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FIGURE 5: CONSUMPTION OF FOOD GROUPS AND COMPONENTS FOR DENMARK AS PER 2016. IMAGES TAKEN FROM:[84].

FIGURE 6: CONSUMPTION OF FOOD GROUPS AND COMPONENTS FOR PORTUGAL AS PER 2016 [87].

Table 2 provides an interpretation of how Denmark and Portugal compare to European and global consumption of food groups and components in 2016, based on Figure 5 and Figure 6. We can observe the following differences between the two countries:

- The Danish consume slightly more calcium and milk than the Portuguese.
- The Portuguese consume more vegetables than the Danish, but the Danish consume more fruit than the Portuguese.
- The Danish consume at lot more processed meats and saturated fat.
- The Portuguese consume more salt.
- The Portuguese drink less sugar-sweetened beverages than the Danish (but Portugal has a sugar-sweetened beverages tax, Denmark does not).

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TABLE 6 ESTIMATED DIFFERENCES BETWEEN DENMARK AND PORTUGAL WHEN COMPARED WITH EUROPE AND THE WORLD ON CONSUMPTION OF FOOD GROUPS AND COMPONENTS IN 2016.

Food group / component	**Denmark**		**Portugal**	
	vs. Europe	*vs. global*	*vs. Europe*	*vs. global*
Calcium	+	++	0	+
Fruit	+	+	0	0
Legumes	-	---	0	---
Milk	+	++	0	+
Nuts and seeds	0	0	0	0
Omega 3	+	0	0	-
Polyunsaturated fat	0	0	0	0
Processed meat	+	+++	---	-
Red meat	+	+++	+	+++
Salt	-	--	+	-
Saturated fat	+	++	0	+
Sugar-sweetened beverages	+	+	-	-
Trans fat	+	-	+	-
Vegetables	-	0	+	+
Whole grain	+	-	0	-

3.3.5.2. Behavioural interventions to promote healthy eating

Given the holistic approach within SmartWork in which healthy nutrition is one of many aspects, dietary assessment introduces a particular challenge as reliable methods for automatic monitoring are still missing. Established self-monitoring methods like keeping a food diary place a high burden on the user and come also with limitations (e.g., recall bias, misreporting, reliance on memory, decline in adherence) [89], [90].

Unlike users who are already motivated to change their current diet and make use of, for example, food diaries, the target group of SmartWork cannot be assumed to be motivated to fill in a diary on

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a daily basis. Within SmartWork, the interventions to promote healthy eating will therefore mainly focus on providing the tools for self-reflection and education to support office workers considering more often healthier eating options. However, SmartWork also aims to increase people's curiosity and motivation by providing achievable, engaging and encouraging challenges.

- **Self-assessment as baseline:** To be able to give the right information at the right time, it is important to gather some information in the beginning. This refers to dietary requirements (such as allergies, personal preferences like veganism, etc.) but also to questions like: What type of food do they prefer? What is their attitude towards food and/or eating healthy? Which part of eating/food do they enjoy? Which changes are they prepared to make, and what is a 'guilty pleasure'?
- **Casual questionnaire:** As was outlined in section 3.3.1, people move through different stages during the behavioural change process and it is therefore necessary to evaluate every now and then, where in the process the person currently is. For example, if a person got frustrated at one point and "relapsed" in the process, it would be counterproductive to suggest even more challenging goals.
- **Challenges:** User can set their own goals or can accept challenges suggested by SmartWork which are supposed to be simple and achievable, to keep them engaged. Depending on where they are in the stage process, these goals could be a more fun short-term challenge (e.g., not drinking coffee for 3 days). If the user is already in the action stage, more long-term challenges of making a small dietary change can be suggested, such as eating two pieces of fruit, drinking enough water, limiting alcohol or caffeine intake and keeping this up for a longer period of time.
- **Sense what is happening:** Depending on the accepted challenge, users are encouraged to record their progress. This can range from checking in that they had a glass of water up to filling in a food diary. Also, provide information on why this is necessary.
- **Provide recipes:** Changing eating patterns can be very challenging and searching for appropriate recipes for a healthy dish can be very time consuming. SmartWork therefore supports the user by providing recipes based on their personal preferences indicated in the self-assessment in combination with the potential challenge that the user might have accepted and/or data they recorded in the food diary. For example, if a user has indicated a nut allergy and has set a 3-day vegan challenge, only vegan recipes without nuts are suggested.
- **Provide reminders:** Reminders are set especially for people who are already in the action stage (e.g., for filling in the food diary or performing acts that correspond to their set goals).
- **Rewards**: The user is given virtual rewards when challenge is accomplished in the SmartWork system. These gamified elements are likely to encourage users to achieve his/her goals.

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- **Provide health education/information:** To prevent the user to be overwhelmed by information, frequency and density of educational information on benefits of healthy nutrition should be tailored to the stage in the change process. As discussed by Prochaska and DiClemente [46], people are most likely to respond to feedback and education once they are in contemplation stage. Depending on the personal preferences and requirements, the current challenges, motivation and stage, tailored information is provided. For example: a person in the "drink enough water" challenge receives a tailored message that relates to their progress, encourages the person, and gives information why drinking water is important. This could be combined with other challenges, for instance coffee intake in combination with sleep duration and quality. Many resources exist that can be used for this purpose, e.g. the Nutriageing website (The PERSSILAA Consortium, 2014-2016) or the websites of the national food institutes of respectively Denmark and Portugal.

LISTED AND NUMBERED INTERVENTIONS

TABLE 7 INTERVENTIONS FOR HEALTHY EATING

Rationale for intervention			
Group/ID	**Name**	**Description**	**Rationale**
BIPNW_HN_IN1	Self-assessment at baseline	Set of questionnaires presented at baseline for assessing current practices, goals and attitude related to healthy eating	Induce self-reflection and identify motivational profile of the user
BIPNW_HN_IN2	Casual questionnaire	Set of questionnaires to evaluate the user's current stage in the process.	Induce self-reflection and identify changes in the motivational profile of the user
BIPNW_HN_IN3	Challenges	The system allows to set individual or group challenges to foster extrinsic motivation to eat healthy.	Self-Determination Theory

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BIPNW_HN_IN4	Sense what is happening	The system encourages user to provide information regarding progress related to milestones / challenges. System provides feedback on the current activity (why this is important).	Social Cognitive Theory
BIPNW_HN_IN5	Provide recipes	The system will provide recipes that based on user preferences and goals/challenges.	Social Cognitive Theory
BIPNW_HN_IN6	Provide reminders	The system will remind the user of the time of activities related to accepted challenges (BIPNW_HE_IN3).	Increase likelihood that the user will commit to the accepted challenges.
BIPNW_HN_IN7	Rewards	The system provides virtual rewards when a milestone is met.	Self-Determination Theory
BIPNW_HN_IN8	Provide health education/information	The system provides educational material for healthy eating.	Social Cognitive Theory

Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
BIPNW_HN_TR1	Event-triggered at the baseline	Provide a set of questions to the user in form of questionnaires or via a conversational agent. Store the relevant parameters for the user model.	Answer the questions provided by the system.
BIPNW_HN_TR2	Time-triggered or event-triggered in	Provide a set of questions to the user in form of questionnaires or via a conversational agent. Store the	Answer the questions provided by the system.

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	case the user is inactive in this module	relevant parameters for the user model.	
BIPNW_HN_TR3	Time-triggered	Once a week provide a suggestion for a 3-day challenge from the list of challenges available for healthy eating.	Accept or reject the challenge.
BIPNW_HN_TR4	User-triggered or Event-triggered	User has an ongoing challenge. The user reports the progress (Ut); System requests a progress report in case the user accepted a challenge but has not reported it themselves (Et). Inform the user when reaching a goal / accomplishing a challenge.	Report progress
BIPNW_HN_TR5	Event-triggered (Et) / Time-triggered (Tt) in case a particular challenge was accepted or User-triggered (Ut)	Provide a recipe that matches the user preference and the challenge that was accepted (Et). During an ongoing challenge suggest a recipe matching preference, goal, and dish matching time (Tt). The user asks for a suggestions (Ut)	Accept or reject the suggested recipe.
BIPNW_HN_TR6	Time-triggered (Tt)	Inform the user that it is almost time for a planned activity (Tt)	Acknowledge reading the message.
BIPNW_HN_TR7	Event-triggered	Provide and store a virtual reward every time the user reaches a milestone / accomplished a challenge.	NA.
BIPNW_HN_TR8	Time-triggered (Tt) or User-triggered (Ut)	The system provides educational content (Tt), the users asks for content (Ut).	Acknowledge reading the message.

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3.3.6. Wellbeing

3.3.6.1. Positive Health

In the previous sub-sections, we have looked at three domains of health: physical activity, nutrition and sleep. However, it is now generally accepted that healthy ageing goes beyond avoidance of illness. The concept of *positive health* stresses the potential to be and to become healthy, even in the presence of illness. One of the biggest contributors to the positioning of positive health in practice is Machteld Huber, who in 2011 proposed defining health as 'the ability to adapt and to self-manage in the face of physical, emotional and social challenge' [91]. Building on this definition, Huber operationalized the concept of positive health by categorizing 556 health indicators into six dimensions: **bodily functions**, **mental wellbeing**, **meaningfulness**, **quality of life**, **participation** and **daily functioning** [92]. The position of the individual in each one of the six dimensions is often visualized in the format of a web diagram, as illustrated in Figure 7. Within SmartWork, the behavioural change interventions focused on wellbeing will aim to create awareness about the multidimensionality of health among the older office workers. To this end, we foresee the following interventions:

- **Self-assessment at baseline**: Based on a pre-defined set of questions for each on the six dimensions of positive health, this strategy aims to delineate the individual web diagram of the user;
- **Provide feedback on positive health**: The user is shown his personal positive health web diagram;
- **Inform "how" (positive health)**: After identifying the weaker elements on the positive health web diagram, the SmartWork system will provide advise on how to work on the specific domain. This advice can be provided on the smartphone, desktop or via a periodically newsletter;
- **Follow-up assessment**: As planned in *D2.3: Data Collection Protocol*, the SmartWork system will be used for a period of 8 weeks in the trial operation in semi-controlled environments and 6 months in the field trials with end-users. In this way, we suggest doing a monthly follow-up assessment of positive health and show to the user the changes over time (i.e. one web line per assessment).

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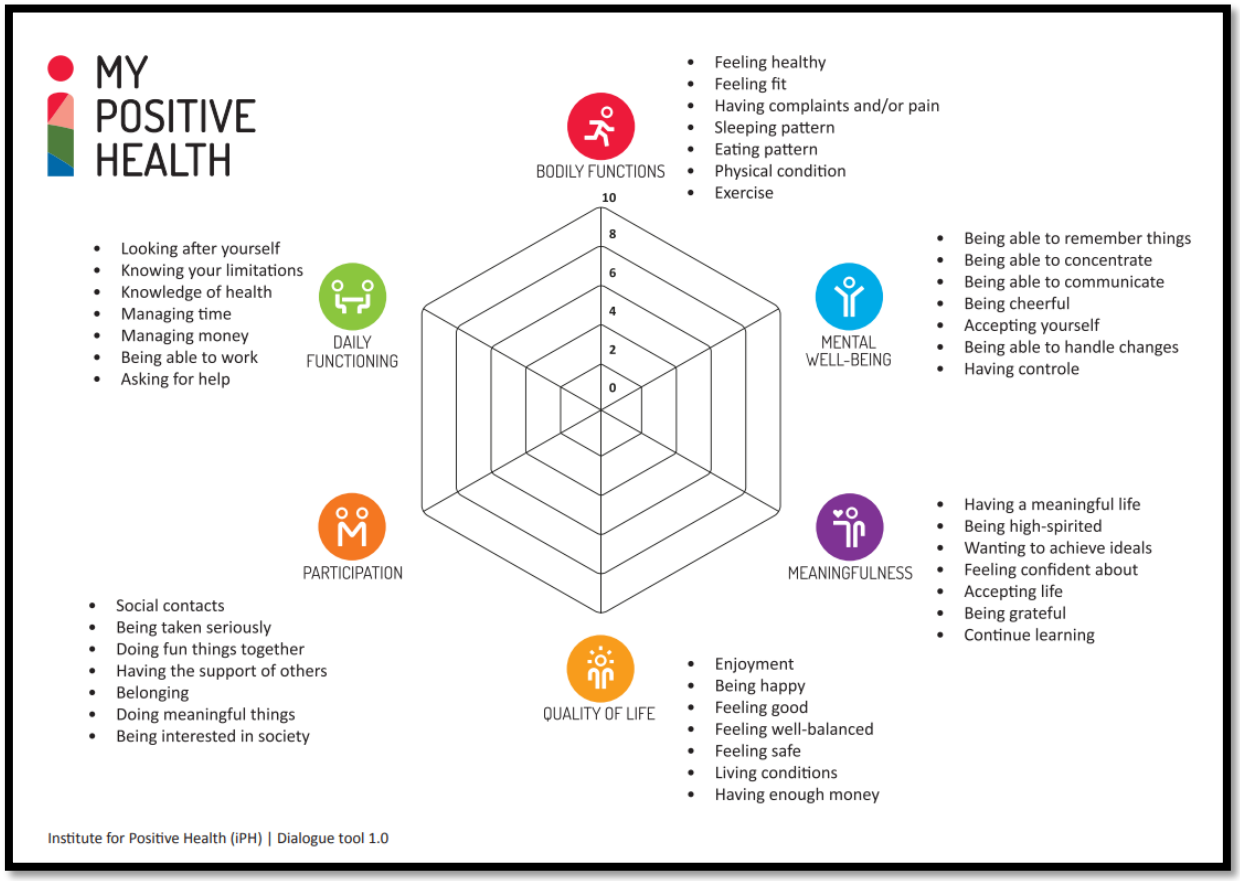

FIGURE 7 - THE SIX DIMENSIONS OF THE CONCEPT OF POSITIVE HEALTH, VISUALIZED IN A WEB DIAGRAM[8] .

3.3.6.2. Long-term overview of momentary assessments

Section 3.4 describes the cognitive function interventions to maintain cognitive capacity mainly through Cognitive State Estimation during working times. These momentary assessments of emotional wellbeing, stress and mental fatigue can be compiled to provide an overview of trends to the user. Therefore, the last foreseen intervention related to the wellbeing domain is:

- **Provide trends of momentary assessments of cognitive state estimation:** Show results of the momentary assessments of cognitive state estimation in a timeline to induce self-reflection on the parameters monitored.

[8] Available at https://iph.nl/download/dialogue-tool/)

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LISTED AND NUMBERED INTERVENTIONS

TABLE 8: INTERVENTIONS FOR WELLBEING.

Rationale for intervention			
Group/ID	Name	Description	Rationale
BIPNW_WB_IN1	Self-assessment at baseline	Assess the current status of the user in each one of the six categories of positive health: bodily functions, mental wellbeing, meaningfulness, quality of life, participation and daily functioning.	Induce self-reflection.
BIPNW_WB_IN2	Provide feedback on positive health	Provide feedback by means of a web diagram on the current situation of the user in the several categories of positive health.	Social Cognitive Theory
BIPNW_WB_IN3	Inform "how" (positive health)	Tips to support the user working towards an improvement of his/her health based on the categories identified in positive health.	Self-Determination Theory
BIPNW_WB_IN4	Follow-up assessment	Re-assess the status of the user in what concerns the different categories of positive health.	Induce self-reflection.
BIPNW_WB_IN5	Provide trends of momentary assessments of cognitive state estimation	Provide feedback my means of long-term overview of the momentary assessments performed within the cognitive assessment estimation.	Induce self-reflection.

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Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
BIPNW_WB_TR1	Event-triggered at the baseline	Provide a set of questions to the user in form of questionnaires or via a conversational agent. Store the relevant parameters for the user model.	Answer the questions provided by the system
BIPNW_WB_TR2	User-triggered	Provide an illustration of the individual positive health web diagram of the user. Always available upon request of the user.	N.A.
BIPNW_WB_TR3	Time-triggered (Tt) or user-triggered (Ut)	On a weekly basis (Tt) or upon request by the user (Ut) the system provided tips on how to work in the several domains of positive health.	N.A.
BIPNW_WB_TR4	Time-triggered (Tt)	Every month the system will repeat the set of questions provided at baseline.	Answer the questions provided by the system
BIPNW_WB_TR5	User-triggered	Upon user request, provide a time-based overview of the parameters assessed through the cognitive state estimation (e.g. stress and mental fatigue).	N.A.

3.3.7. Relationship to SmartWork tools, training modules and services implementation

healthyMe is the core SmartWork service that will implement the behavioural interventions. The data will be collected via the unobtrusive sensor network, automatically using sensors (e.g. physical activity tracker) or by direct input from the user (e.g. questionnaires).

Behavioral interventions to promote physical activity, sleep, healthy nutrition and wellbeing			
SW Services	**SW Interventions**	**SW Modelling**	**SW Data**
HealthyMe MyWorkability	Lifestyle interventions Short- and long-term	Monitoring Controller & Low-Level	User Data Needs & Preferences

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	health risks prediction Work Ability prediction	Processing (health data, lifestyle, activity, psychology) Modelling toolbox (functional modelling, emotion modelling, work ability modelling)	profile Work Ability data Emotion data

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3.4. Cognitive function interventions to maintain cognitive work capacity

Interventions initiated by the CSE part of the SmartWork system are modularized by separating out three parts:

1. Alerting the user—The user is alerted of a disadvantageous cognitive state, for example, high mental workload. The user is asked to acknowledge or reject the alert.

2. Eliciting feedback from the user—The user is asked to fill out a brief questionnaire to provide his/her subjective experience of a given cognitive state, for example, to what degree the user feels mentally fatigued.

In connection with interventions, elicitation of user feedback for the purpose of obtaining training data for machine learning, will be initiated occasionally, when the Cognitive State Estimation (CSE) signals for this. Elicitation for user feedback, in the form of questionnaires, will be used sparingly, to a greater extent initially, when the CSE is still under training, and less frequently during later stages of the project, when the CSE has reached a maturity, where only minor fine-tuning to the individual user is necessary.

3. Supporting the user—The user is offered advice on ways to mitigate unfavourable cognitive states, such as mental fatigue, work-induced stress, et cetera.

The development of the CSE will go through three phases:

I. Initial training of the CSE. During this phase, the CSE will not initiate any alerts or supportive advice. The CSE will instead only elicit users' feedback at regular time intervals on all mental states that the CSE is trained on. The reason for not alerting and supporting at this stage, is that the user's cognitive state cannot be estimated, hence the user cannot be alerted, before the CSE has been sufficiently trained.

II. Continued training of the CSE. In this phase, the CSE will initiate alerts when it judges it appropriate based on cognitive state estimations. After the alert has been delivered, user feedback will be elicited concerning also other cognitive states, besides the one that the user was alerted about.

III. Fine-tuning of the CSE (with users in the final trials), where the CSE is fine-tuned to individual users during real-life operation. In this phase, alerts will be initiated, followed by elicitation of the user's subjective experience of the cognitive state that was alerted on, and finally supportive advice on possible ways to handle the cognitive state, and improve the user's workflow and productivity.

An important part of interventions on cognitive states is the collection of the office workers' feedback on how they themselves experience their own mental state. This feedback will be used to improve the AI-algorithms (machine learning) of the CSE. So, while the CSE-module of SmartWork system is under development, collection of user feedback will be triggered periodically, and these

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data will be used to train the AI-machine learning. As the CSE-module becomes more knowledgeable of the reliable indicators of stress, distraction, et cetera, so that the CSE can more reliably recognize these cognitive states when observing the office worker's actions, the SmartWork system will intelligently alert the user when it detects unfavourable cognitive states, and offer supportive advice on how to maintain well-being and productivity, without requiring extensive user feedback.

3.4.1. Motivations for intervention

Several personas, specified in detail in deliverable D2.2, describe use cases where long working hours have to be spent in front of a laptop or desktop computer.

> *" … most of the working hours is spent **at her desk and desktop**"*
>
> *"Working at the desktop, she **uses MS Office, internet and email programmes**"*
>
> *"… she also wants to be able to **work at home** … with secure internet connection"*
>
> User scenario Persona 4 Birgit

In addition to periodically having long working hours in front of a computer, Birgit, our 60-years' old office worker, has diabetes, which renders her extra sensitive to the negative effects of stress, task overload, and mental fatigue.

The main motivation of monitoring cognitive state during office work is to support the office worker in maintaining a personally satisfying level of productivity. This may entail, for example, that the office worker tries to avoid getting unwillingly distracted, and to not take too long spontaneous (unplanned) breaks during a planned work session. In these situations, an office worker might appreciate receiving support through alerts and getting advice on how to get back on track. On the other hand, it is equally important to find time to relax and recharge batteries, when the office worker becomes mentally fatigued. This situation may not be easy to detect without external support. So, also, in this situation, an alert and guidance can be very useful: Alert that one is getting mentally fatigued and guidance as to which revitalizing activities one could use to regain energy, and to be able to efficiently resume one's work tasks.

The support offered to an office worker will be automatically adapted on the basis of the feedback the office worker provides to the system. The office worker might, for example, answer that she is not fatigued, when alerted for apparent signs of mental fatigue. By refuting that this is the case, the office worker prompts the system to adjust (reprofile) how his/her mouse actions, eye movement patterns, and physiological data should be interpreted.

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3.4.2. Listed and numbered interventions

3.4.2.1. Alerts from the CSE

CIMCC_AL1: CSE_alert_mental_fatigue (*user_uuid, time_of_occurance*)

Condition: If the CSE has estimated that the user is mentally fatigued, judged from the user's mouse actions, eye movement patterns, physiological measurements, and other work environment data.

Required user interaction: Display pop-up "You seem to be worn out." Let the user acknowledge the alert with "Yes, I am", or "No, I am not". Return 0 or 1, together with *user_uuid,* and *time_of_occurance* received in the original call.

NOTE: There may also be an elicitation for more elaborate user feedback in the form of brief questionnaire(s) (see section 3.4.2.2 below). In case there is a matching elicitation, that is, CSE_elicit_**mental_fatigue** (which has matching name), the above Yes/No question should be replaced by the more elaborate questions in the elicitation, as the elicitation questions make Yes/No redundant.

CIMCC_AL2: CSE_alert_high_workload (*user_uuid, time_of_occurance*)

Condition: When the CSE has estimated that the user has high mental workload, judged from the user's mouse actions, eye movement patterns, and physiological measurements, and other work environment data.

Display pop-up "You seem to be overwhelmed (high workload)." Let the user acknowledge with "Yes, there is too much going on" or "No, I could handle even more tasks". Return 0 or 1, together with *user_uuid,* and *time_of_occurance.*

NOTE: There may also be an elicitation for more elaborate user feedback in the form of brief questionnaire(s) (see section 3.4.2.2 below). In case there is a matching elicitation, that is, CSE_elicit_**high_workload** (which has matching name), the above Yes/No question should be replaced by the more elaborate questions in the elicitation, as the elicitation questions make Yes/No redundant.

CIMCC_AL3: CSE_alert_task_related_stress (*user_uuid, time_of_occurance*)

Condition: When the CSE has estimated that the user is stressed, judged from the user's mouse actions, eye movement patterns, and physiological measurements, and other work environment data.

Display pop-up "You seem to be stressed." Let the user acknowledge with Yes/No. Return 0 or 1, together with *user_uuid,* and *time_of_occurance.*

NOTE: There may also be an elicitation for more elaborate user feedback in the form of brief questionnaire(s) (see section 3.4.2.2 below). In case there is a matching elicitation, that is, CSE_elicit_**task_related_stress** (which has matching name), the above Yes/No question

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should be replaced by the more elaborate questions in the elicitation, as the elicitation questions make Yes/No redundant.

CIMCC_AL4: CSE_alert_distraction (*user_uuid, time_of_occurance*)

Condition: When the CSE has estimated that the user has been distracted, judged from the user's mouse actions, eye movement patterns, and physiological measurements, and other work environment data.

Display pop-up "You seem to have difficulty to concentrate." Let the user acknowledge with Yes/No. Return 0 or 1, together with *user_uuid,* and *time_of_occurance.*

NOTE: There may also be an elicitation for more elaborate user feedback in the form of brief questionnaire(s) (see section 3.4.2.2 below). In case there is a matching elicitation, that is, CSE_elicit_**distraction** (which has matching name), the above Yes/No question should be replaced by the more elaborate questions in the elicitation, as the elicitation questions make Yes/No redundant.

CIMCC_AL5: CSE_alert_task_switch (*user_uuid, time_of_occurance*)

Condition: When the CSE has estimated that the user has switched computer work task, judged from the user's mouse actions, eye movement patterns, and physiological measurements, and other work environment data, such as which windows on the office worker's computer screen have been active recently.

Display pop-up "You seem to have switched task?" Let the user acknowledge with Yes/No. Return 0 or 1, together with *user_uuid,* and *time_of_occurance.*

NOTE: There may also be an elicitation for more elaborate user feedback in the form of brief questionnaire(s) (see section 3.4.2.2 below). In case there is a matching elicitation, that is, CSE_elicit_**task_switch** (which has matching name), the above Yes/No question should be replaced by the more elaborate questions in the elicitation, as the elicitation questions make Yes/No redundant.

3.4.2.2. Elicitations of user feedback from the CSE

During phase I), that isduring initial training of the CSE, elicitations will be periodically initiated in order to obtain necessary training data, *even if no alerts have been raised.* Elicitations will, as much as possible, be delayed until a work task has been finalized by the user. In this way, elicitations will be displayed at natural pauses in the user's work activities.

In order to prompt the user to the task that he/she has just finished, the task_name of the just finished task will be used.

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CIMCC_QN1: CSE_elicit_mental_fatigue (*user_uuid, time_of_occurance, task_name*)

Present the following question on mental fatigue (adapted from RAND SF-36[9], questions 23, 27, 29, 31):

"When working with [*task_name*], how fatigued/worn out did you feel?"

Use a Likert scale with 5 possibilities. Radio buttons with the following text: "Not at all" "Slightly" "Moderately" "Very" "Extremely"[10]. For final score, transform the answer [1, 2, 3, 4, 5] into the interval [0 1].

CIMCC_QN2: CSE_elicit_high_workload (*user_uuid, time_of_occurance, task_name*)

Present question on mental workload, adapting NASA-TLX [93]:

"When working with [*task_name*] …" (elaborations within parenthesis, not necessary to show on every occasion an elicitation is done; show only upon long-click/"hover")

Mental demand: "… how mentally demanding was the task?" (Was the task easy or demanding, simple or complex?)

Temporal demand: "… how hurried or rushed was the pace of the task?" (How much time pressure did you feel due to the pace at which the tasks or task elements occurred?)

Overall performance: "… how successful were you in accomplishing the task?" (How successful were you in accomplishing the goals of the task? How satisfied were you with your performance?)

Effort: "… how hard did you have to work to accomplish your level of performance?" (How hard did you have to work (mentally and physically) to accomplish your level of performance?)

Frustration level: "… how insecure, discouraged, irritated, stressed, and annoyed were you?" (How irritated, stressed, and annoyed versus content, relaxed, and complacent did you feel during the task?)

Use a scale with 21 ticks, label the extremes with "low" and "high"[11]. Let the user click on any position on the line. For scores, transform the interval [0 20] to the interval [0 1]. Return one score for each of the above questions, e.g. [.3 .6 .8 1 .1].

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[9] For the original items, see https://www.rand.org/health-care/surveys_tools/mos/36-item-short-form/survey-instrument.html

[10] Iowa State University Likert scale examples: https://www.extension.iastate.edu/Documents/ANR/LikertScaleExamplesforSurveys.pdf

[11] iOS app of the NASA-TLX: https://humansystems.arc.nasa.gov/groups/TLX/tlxapp.php

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CIMCC_QN3: CSE_elicit_task_related_stress (*user_uuid, time_of_occurance, task_name*)

Run stress profiling using an adapted, that is, shortened form of the Dundee Stress State Questionnaire (DSSQ) [94]–[96]. We want to measure two of the original three overarching stress factors: task engagement and distress (see Table 1 in [94] for factor analysis of the items in DSSQ).

"While engaging in [*task_name*] ...":

(*Task engagement*)

(Energetic arousal) "I felt vigorous."

(Task interest) "The content of the task was interesting."

(Success motivation) "I wanted to perform better than most people do."

(Concentration) "My mind was wandering a great deal"

(Distress)

(Tension) "I felt nervous."

(Hedonic tone (low)) "I felt contented (happy/satisfied)."

(Confidence, control (low)) I felt confident in my abilities.

Text in parenthesis should *not* be displayed to the user. Use a 5-step Likert scale for the seven questions above. "Not at all" "Slightly" "Moderately" "Very" "Extremely"[12]. For final score, transform the answers [1, 2, 3, 4, 5] into the interval [0 1]. Return one score for each of the questions.

CIMCC_QN4: CSE_elicit_distraction (*user_uuid, time_of_occurance*)

This elicitation occurs when the user has been looking away from the active window or has been frequently switching between windows. Present choices (radio button style) for eliciting the user's time off of work task. Eliciting question: "For how long you have been distracted away from your main activity?" Use the following choices [97]:

1: For < 1 minute (e.g. glancing at clock, glancing at other windows on computer)
2: For 2-3 minutes (e.g. checking email or sending text messages (sms))
3: For > 5 minutes (e.g. googling, watching Youtube)

Text in parenthesis displayed upon long click/"hover". Return 1, 3, or 5 (min)

[12] Iowa State University Likert scale examples:
https://www.extension.iastate.edu/Documents/ANR/LikertScaleExamplesforSurveys.pdf

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CIMCC_QN5: CSE_elicit_task_switch (*user_uuid, time_of_occurance, prev_task_name, current_task_name*)

This elicitation occurs when the user is inferred to have been off main work task for a while (e.g., 5 minutes). The purpose of the elicitation is to get user feedback, and subsequently if necessary, to "nudge" the user to return back to work—just like it would be done in a productivity app.

Ask the user: "Is [*current_task_name*] related to your previous task: [*prev_task_name*]?"

Two possible answers: Yes, it is related to my previous task. No: → provide a choice (e.g. dropdown) between "I'm relaxing, resting" or "I'm working on a different task now" → in this latter case, provide a choice between "communication (e.g. answer email)", "planning (e.g. scheduling)", "authoring (e.g. filling out a form)", "reading (e.g. documents)", "information search (e.g. Google)", "self-education (e.g. online courses/tutorials)"

3.4.2.3. Supportive CSE-advices to the user

CIMCC_SU1: CSE_support_mental_fatigue (*user_uuid, time_of_occurance*)

Suggest that the user should take a short break, until the user feels reenergized. (5 minutes into such a relaxation break, the support_user_task_switch call will be initiated, nudging the user to get back to work.)

System actions: Ask user if it is OK to turn on dark mode, increase font sizes, increase contrast

Environment: decrease ambient noise level, adjust temperature

CIMCC_SU2: CSE_support_high_workload (*user_uuid, time_of_occurance*)

Suggest that the user should take a step back, and reprioritize the tasks currently engaged in, and to only focus on the top-priority task.

More long-term, the user might want to talk to management and ask for re-allocation of tasks/resources to avoid recurring overload.

CIMCC_SU3: CSE_support_task_related_stress (*user_uuid, time_of_occurance*)

Suggest that the user should take a short rest break. The user might also want to break down tasks into smaller, more manageable chunks of 25-30 minutes and work with them one at a time.

More long-term, the user might want to talk to management and ask for re-allocation of tasks/resources, and let the user have more control over the pace of the tasks. Most importantly, management should be made aware that the user might benefit from more (explicit) appraisal (e.g. increased salary).

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Stress can also be alleviated by increased user engagement in the task, and direct positive feedback on the user's performance [98]. Hence, it can be productive to match tasks that suits (engages) the user, and also let management or the work environment itself provide positive feedback whenever possible.

CIMCC_SU4: CSE_support_distraction (*user_uuid, time_of_occurance*)

Is called when the user is freuently switching to unrelated tasks, and/or frequently looking away from the active window. Suggest that the user should take a brief relaxation brake, and then resume work. (5 minutes into a relaxation break, the support_user_task_switch call will be initiated, nudging the user to get back to work.)

CIMCC_SU5: CSE_support_task_switch (*user_uuid, time_of_occurance*)

If the current (last 5 minutes') activity was not a work-related task, "nudge" the user into resuming work by asking: "What is your work goal for the next 15-30 minutes? (What do you plan to achieve during the next 15 to 30 minutes?) The user should choose between a number of predetermined task categories, such as: "communication (e.g. answer email)", "planning (e.g. scheduling)", "authoring (e.g. fill out form)", "reading (e.g. documents)", "information search (e.g. Google)", "self-education (e.g. online courses/tutorials)"

TABLE 9 INTERVENTIONS FOR FATIGUE, WORKLOAD, STRESS AND DISTRACTION

Rationale for intervention			
Group/ID	**Name**	**Description**	**Rationale**
CIMCC_AL1	CSE_alert_mental_fatigue	Alert the user of mental fatigue (for details see section 3.4.2.1)	- Help the user become aware. Avoid inefficient work. - Collect data for training the CSE.
CIMCC_AL2	CSE_alert_high_workload	Alert the user of high workload (for details see section 3.4.2.1)	- Help the user become aware. Prevent mental "burnout". - Collect data for training the CSE.
CIMCC_AL3	CSE_alert_task_related_stress	Alert the user of task related stress (for details see section 3.4.2.1)	Help the user become aware. Prevent "burnout". - Collect data for training the CSE.

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CIMCC_AL4	CSE_alert_distraction	Alert the user of distraction (for details see section 3.4.2.1)	Help the user become aware. Help focus. - Collect data for training the CSE.

Rationale for intervention – cont.			
Group/ID	**Name**	**Description**	**Rationale**
CIMCC_AL5	CSE_alert_task_switch	Alert the user of task switch (for details see section 3.4.2.1)	Help the user become aware. Prevent mental "burnout". - Collect data for training the CSE.
CIMCC_QN1	CSE_elicit_mental_fatigue	Get information on how mentally fatigued the user is. (using 1 question). (For details see section 3.4.2.2)	- Collect data for training the CSE.
CIMCC_QN2	CSE_elicit_high_workload	Get information on mental workload (using 6 questions; NASA-TLX). (For details see section 3.4.2.2)	- Collect data for training the CSE.
CIMCC_QN3	CSE_elicit_task_related_stress	Get information on how stressed the user feels (Using 7 questions; DSSQ). (For details see section 3.4.2.2)	- Collect data for training the CSE.
CIMCC_QN4	CSE_elicit_distraction	Get information on how long the user has been distracted (Using 3 questions) (For details see	- Collect data for training the CSE.

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		section 3.4.2.2)	
CIMCC_QN5	CSE_elicit_task_switch	Get information on the nature and relation between previous and current task (using a hierarchy of 3 questions) (For details see section 3.4.2.2)	- Collect data for training the CSE.

Rationale for intervention – cont.			
Group/ID	**Name**	**Description**	**Rationale**
CIMCC_SU1	CSE_support_mental_fatigue	Suggest user to - take a rest - adjust screen settings - adjust environment (temp, noise, etc.) (For details see section 3.4.2.3)	Help the user mitigate fatigue. Promote efficient work.
CIMCC_SU2	CSE_support_high_workload	Suggest user to - only deal with highest prio tasks - talk to management for reallocation of tasks (For details see section 3.4.2.3)	Help the user alleviate high workload. Prevent mental "burnout"
CIMCC_SU3	CSE_support_task_related_stress	Suggest user to - take a reenergizing break - break down tasks and take one small task at a time - ask management	Help the user relieve stress. Prevent work-related "burnout"

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		for more engaging tasks (For details see section 3.4.2.3)	
CIMCC_SU4	CSE_support_distraction	Suggest user to - take a mindful/refocusing break (For details see section 3.4.2.3)	Help the user refocus.
CIMCC_SU5	CSE_support_task_switch	Ask user what work plans for the coming 20-30 minutes ("nudging" the user into work-mode) (For details see section 3.4.2.3)	Help the user get back on track.

Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
CIMCC_AL1	CSE_alert_mental_fatigue (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display pop-up "You seem to be worn out." - Return 0 or 1 depending on user feedback, together with the in-params *user_uuid*, and *time_of_occurance*. (For details see section 3.4.2.1) NOTE: If corresponding call CIMCC_QN1 is present, skip Yes/No, and display the questions for CIMCC_QN1 instead.	- The user acknowledges the alert with "Yes, I am" or "No, I'm not".
CIMCC_AL2	CSE_alert_high_workload	- Display pop-up "You seem to be overwhelmed	- The user acknowledges

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	(*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	(high workload)." (For details see section 3.4.2.1) - Return 0 or 1, together with *user_uuid*, and *time_of_occurance*. (For details see section 3.4.2.1) NOTE: If corresponding call CIMCC_QN2 is present, skip Yes/No, and display the questions for CIMCC_QN2 instead.	the alert with "Yes, I am" or "No, I'm not".

Technical specification – cont.			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
CIMCC_AL3	CSE_alert_task_related_stress (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display pop-up "You seem to be stressed." - Return 0 or 1, together with *user_uuid*, and *time_of_occurance*. (For details see section 3.4.2.1) NOTE: If corresponding call CIMCC_QN3 is present, skip Yes/No, and display the questions for CIMCC_QN3 instead.	- The user acknowledges the alert with "Yes, I am" or "No, I'm not".
CIMCC_AL4	CSE_alert_distraction (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display pop-up "You seem to have difficulty to concentrate." - Return 0 or 1, together with *user_uuid*, and *time_of_occurance*. (For	- The user acknowledges the alert with "Yes, I am" or "No, I'm not".

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		details see section 3.4.2.1) NOTE: If corresponding call CIMCC_QN4 is present, skip Yes/No, and display the questions for CIMCC_QN4 instead.	
CIMCC_AL5	CSE_alert_task_switch (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display pop-up "You seem to have switched task?" - Return 0 or 1, together with *user_uuid*, and *time_of_occurance* (For details see section 3.4.2.1) NOTE: If corresponding call CIMCC_QN5 is present, skip Yes/No, and display the questions for CIMCC_QN5 instead.	- The user acknowledges the alert with "Yes, I am" or "No, I'm not".

Technical specification – cont.			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
CIMCC_QN1	CSE_elicit_mental_fatigue (*user_uuid, time_of_occurance, task_name*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display "When working with [*task_name*], how fatigued/worn out did you feel?" - For final score, transform the answer [1, 2, 3, 4, 5] into the interval [0 1]. (For details see section 3.4.2.2)	User marks on a Likert scale with 5 possibilities: "Not at all" "Slightly" "Moderately" "Very" "Extremely"
CIMCC_QN2	CSE_elicit_high_workload (*user_uuid, time_of_occurance,*	- Run the NASA-TLX questionnaire (6 questions)	User marks on 6 scales with 21 ticks (0 – 20),

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	task_name) (As http(s) request, with jwt access token in header, and params in body (json))	- For scores, transform the interval [0 20] to the interval [0 1]. Return one score for each question. (For details see section 3.4.2.2)	extremes labelled with "low" and "high"
CIMCC_QN3	CSE_elicit_task_related_stress (*user_uuid, time_of_occurance, task_name*) (As http(s) request, with jwt access token in header, and params in body (json))	- Run the short version of DSSQ questionnaire (7 questions). - For scores, transform each answer [1, 2, 3, 4, 5] into the interval [0 1]. (For details see section 3.4.2.2)	For each question, the user marks on a Likert scale with 5 possibilities: "Not at all" "Slightly" "Moderately" "Very" "Extremely"
CIMCC_QN4	CSE_elicit_distraction (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display "For how long you have been distracted away from your main activity?" - Return 1, 3, or 5 (min) (For details see section 3.4.2.2)	User chooses from 3 options: 1: < 1 minute 2: 2-3 minutes 3: > 5 minutes

Technical specification – cont.			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
CIMCC_QN1	CSE_elicit_mental_fatigue (*user_uuid, time_of_occurance, task_name*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display "When working with [*task_name*], how fatigued/worn out did you feel?" - For final score, transform the answer [1, 2, 3, 4, 5] into the interval [0 1]. (For details see section	User marks on a Likert scale with 5 possibilities: "Not at all" "Slightly" "Moderately" "Very" "Extremely"

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		3.4.2.2)	
CIMCC_QN2	CSE_elicit_high_workload (*user_uuid, time_of_occurance, task_name*) (As http(s) request, with jwt access token in header, and params in body (json))	- Run the NASA-TLX questionnaire (6 questions) - For scores, transform the interval [0 20] to the interval [0 1]. Return one score for each question. (For details see section 3.4.2.2)	User marks on 6 scales with 21 ticks (0 – 20), extremes labelled with "low" and "high"
CIMCC_QN3	CSE_elicit_task_related_stress (*user_uuid, time_of_occurance, task_name*) (As http(s) request, with jwt access token in header, and params in body (json))	- Run the short version of DSSQ questionnaire (7 questions). - For scores, transform each answer [1, 2, 3, 4, 5] into the interval [0 1]. (For details see section 3.4.2.2)	For each question, the user marks on a Likert scale with 5 possibilities: "Not at all" "Slightly" "Moderately" "Very" "Extremely"
CIMCC_QN4	CSE_elicit_distraction (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	- Display "For how long you have been distracted away from your main activity?" - Return 1, 3, or 5 (min) (For details see section 3.4.2.2)	User chooses from 3 options: 1: < 1 minute 2: 2-3 minutes 3: > 5 minutes

Technical specification – cont.			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
CIMCC_QN5	CSE_elicit_task_switch (*user_uuid, time_of_occurance, prev_task_name, current_task_name*) (As http(s) request, with jwt	- Display "Is [*current_task_name*] related to your previous task: [*prev_task_name*]?" - Return name of chosen	User chooses from a hierarchy of options.

	access token in header, and params in body (json))	category (string) (For details see section 3.4.2.2)	
CIMCC_SU1	CSE_support_mental_fatigue (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	Suggest user to - take a rest - adjust screen settings - adjust environment (temp, noise, etc.) (For details see section 3.4.2.3)	
CIMCC_SU2	CSE_support_high_workload (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	Suggest user to - only deal with highest prio tasks - talk to management for reallocation of tasks (For details see section 3.4.2.3)	
CIMCC_SU3	CSE_support_tasl_related_stress (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	Suggest user to - take a reenergizing break - break down tasks and take one small task at a time - ask management for more engaging tasks (For details see section 3.4.2.3)	

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Technical specification – cont.			
Group/ID	Triggers	System actions	User actions (feedback)
CIMCC_SU4	CSE_support_distraction (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	Suggest user to - take a mindful/refocusing break (For details see section 3.4.2.3)	
CIMCC_SU5	CSE_support_task_switch (*user_uuid, time_of_occurance*) (As http(s) request, with jwt access token in header, and params in body (json))	Ask user what work plans for the coming 20-30 minutes ("nudging" the user into work-mode) (For details see section 3.4.2.3)	

3.4.3. Relationship to SmartWork tools, training modules and services implementation

The CSE module will make calls to and receive input from several other SmartWork modules and services.

3.4.3.1. Interaction with the user

In their final version, all CSE alerts (CIMCC_AL*), CSE elicitation for user feedback (CIMCC_QN*), and supportive actions (CIMCC_SU*) will be communicated as http requests to the SmartWork module Morphic, so that the user interface is displayed on the same device that the user is currently working on, namely the user's desktop or laptop.

3.4.3.2. Output from CSE

On the output side, support actions, such as changing of colour theme of the user's work computer, changing font size, contrast, et cetera, are also achieved through Morphic[13].

[13] Morphic is a graphics system which uses graphical objects called Morphs for simplified GUI-building allowing for a high degree of flexibility and dynamism.

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Supportive suggestions from the CSE, for example, that the user should request a reallocation of work tasks, and assignment of tasks more adapted to the user (highly engaging tasks in order to alleviate work-related stress), these actions could be implemented through digiTeam, but could also be managed offline (manually) by the user.

When in production (in development phase III), supportive actions from the CSE will be filtered and harmonized with other ongoing interventions through the SmartWork DSS module.

The numerical predictions (cognitive state estimations) produced by the CSE will be stored at SparkWorks cloud, and thereby be made available to all other SmartWorks modules.

3.4.3.3. Sensor input to the CSE

Sensor data, such as ambient noise and environmental temperature, will be uploaded to, and recollected through http requests from SparkWorks. Likewise, physiological data, such as heart rate, skin conductance, will be uploaded to and recollected from SparkWorks. (An alternative is to use the RRD-platform R2D2 hosting the HealthyMe service).

3.5. Work management interventions to reduce work related stress

What is stress and how does it show?

Work-related stress is an emotional and psycho-physiological reaction, a feeling of tension and unease. This often occurs because an employee is faced with requirements that he or she does not have the resources to fulfil. If the employee also has few opportunities to influence the requirements the risk of stress increases further [112].

Reasons for work related stress may be split in three types:

- The classic stress: Pace, monotonous work, low influence, few development opportunities.
- The relational stress: Unclear demands, heavy work pressure, emotional demands, conflicts, violence and threats, low prestige, demanding users.
- The modern stress: Endless demands, many deadlines, unclear boundaries between workhours and leisure, work-life imbalance, lack of predictability, individualized working conditions.

Typical work-related stress reactions are:

- Physical: Palpitations, headaches, shaking of hands, dizziness, tics, abdominal pain, frequent urination, diarrhea, decreased sexual interest, frequent infections, worsening of chronic illnesses and general pain.

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- Mental: Fatigue, inner turmoil, carelessness, memory difficulties, concentration problems, restlessness, sadness, irritability, anxiety, decreased sense of humour, feeling of exhaustion and depressive symptoms.
- Behavioural: Insomnia, low self-esteem, emotional withdrawal, confinement, anger, aggressiveness, impaired performance, indecision, increased use of stimulants, loss of appetite and absenteeism.

Basic stress reduction tools

The most basic stress reduction tools are:

- That employees and management have influence on their own work, be it the content of the work, working methods, times of work effort, etc.
- That there is meaning and coherence in the work, so that the individual can see what he / she contributes to in relation to overall goals
- That as far as possible avoid uncertainty and insecurity in the work, so that every employee knows exactly what requirements are being made·
- That both colleagues and management support the employee professionally and socially, thus achieving a better task solution and motivation
- That there is an element of reward in the work, be it praise, recognition, opportunity for development, career, etc.
- That there is a balance between resources and requirements on the part of the individual

3.5.1. The work management intervention domain

Improving employee well-being and reducing stress can have a number of benefits for organizations, from increasing performance, improving relationships, to reducing sickness and absenteeism rates etc.

Stress management interventions refer to a class of activities that are used by organisations to improve employee well-being and reduce stress, principally by either addressing the causes of stress or by reducing the impact of stress on an individual.

With regard to the level of an intervention, a common and simple distinction is between individual and organisational levels. The individual-level management interventions focus on helping the individual employee to develop skills to manage, cope with and reduce stress, whereas organisational-level management interventions make more systemic changes to organisational practices that either target all employees or a specific group of workers.

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3.5.2. Motivations for intervention

Based on the present uncertainty about the technology and services that SmartWork will cover, a simple approach is taken towards the "ideal" interventions and triggers for work management to reduce work-related stress.

Chapter 3.4 "Cognitive function interventions to maintain cognitive capacity", establish, by a number of interventions and user feedback, the instantaneous mental states of the office worker and supportive advices and guidance for action to the user. These Cognitive function interventions aims at short term stress assessment and support e.g. determining present task-related stress and advice to "take a short break". Work related stress in this chapter is about long-term, life-affecting stress, that short lasting actions would not remedy. Work related stress, is aiming at long term detection on the mental states.

Based to the theory of the 'Triune Brain' Model by neuroscientist Paul McLean [113] we will apply the theory's division of the human brain into three distinct regions. MacLean's model suggests the human brain is organized into a hierarchy, which itself is based on an evolutionary view of brain development. The three regions are as follows:

1. **Reptilian or Primal Brain** (Basal Ganglia)
2. **Paleomammalian or Emotional Brain** (Limbic System)
3. **Neomammalian or Rational Brain** (Neocortex)

The Reptilian or Primal Brain (Basal Ganglia) or "The Autonomous System" is a basic sensory and arousal regulatory level that helps to control our ability for attention and presence as well as energy level, it is the sensory level, where emotions and judgment of our self are rooted in the body. From here, our arousal level is controlled to suit your needs in the present situation. From this part of the brain also arise our bodily sensations, which are triggered in connection with primitive instincts and reflexes, such as battle, escape, stiffen or the opposite of being in a relaxed safe state. It is said that this level of the brain is the root of the emotional life and the physiological basis for being able to feel if something is comfortable or uncomfortable. Building on the research on the Autonomous System, in relation to stress, four emotional states of the Autonomous System [114] are illustrated in figure 2 by the "Autonomous Compass" mental model i.e.: Stress, Satisfaction, Monotony and Rest.

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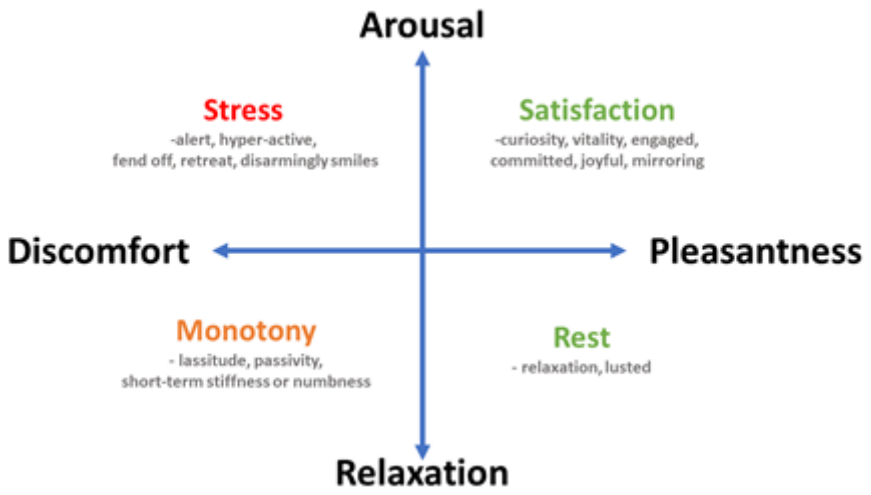

FIGURE 8: THE AUTONOMOUS COMPASS

The Autonomous Compass is used to assess the arousal level on an individual. The vertical axis marks whether the person has a high or low arousal-level. The horizontal axis describes whether a given sensation is pleasant or unpleasant to the individual. One can either be in a high or one low activity level / arousal level and both modes can be experienced as pleasant or unpleasant. The compass states illustrate four mental states normal for all individuals.

Detection of emotional state and hence stress, is captured by the Cognitive State Estimation (CSE) at regular intervals by running the stress profiling using the Dundee Stress State Questionnaire [section 3.4.3.2]: Quote:

> We want to measure two of the original three overarching factors: Task engagement and distress (see Table 1 in [26] for factor analysis of the items in DSSQ).
>
> "While engaging in [*task_name*] ..." (use a 5-step Likert scale for the questions below):
>
> *Task engagement*
>
> *Energetic arousal:* "I felt vigorous."
>
> *Task interest:* "The content of the task was interesting."
>
> *Success motivation:* "I wanted to perform better than most people do."
>
> *Concentration:* "My mind was wandering a great deal"
>
> *Distress*
>
> *Tension:* "I felt nervous."
>
> *Hedonic tone (low):* "I felt contented (happy/satisfied)."
>
> *Confidence, control (low):* I felt confident in my abilities.

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By weighting samples of the four factors of Task engagement, the level of Arousal/Relaxation of the individual office worker can be calculated. The samples represent values of the Likert scale [1; 5]. Similar and synchronous samples of the three Distress parameters are by weighted calculation determined by values of the Likert scale [1; 5]. The two samples constitute a state of stress/non-stress which can be plotted unto the Autonomous Compass mental state model.

To plot the Likert scale values [1; 5] into the Autonomous Compass output area, the neutral value of the Likert scale "3" is off-set to value "0" and Likert "1" and "5" to the negative and positive peripheral of the compass output area.

By performing this iteration regularly (time triggered) and accumulating samples across time, changes and/or concentrations of instances will form a pattern within the mental model, figure 2, representing the long-term statistical metal condition of the office worker. The Intervention consist of presentation of these patterns to the user, together with the option of qualified advice and/or guidance.

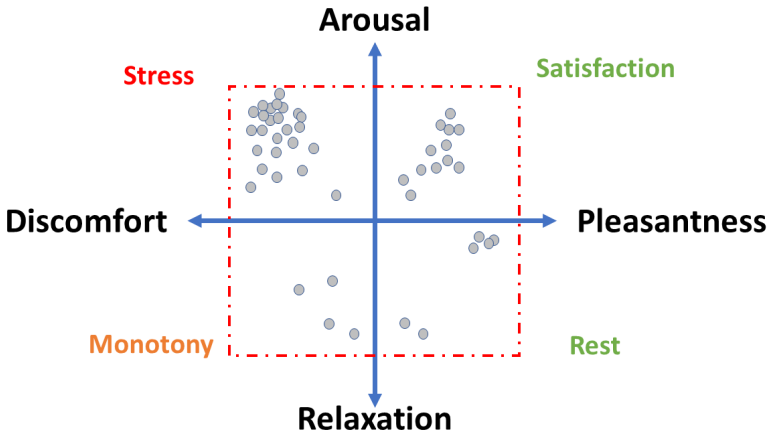

FIGURE 9: PLOTS OF THE EMOTIONAL STATE INSTANCES ACCUMULATED OVER TIME

3.5.3. Work management interventions to reduce work related stress from user stories in D2.2

In this sub-section we provide excerpts of the user scenarios provided in Deliverable 2.2., concerning work management interventions within the SmartWork system to reduce work stress.

Although António tried to do his best to learn the new tools and paradigms, the work is not completely easy to him as he had no knowledge at all on working with computers and paper files and in fact these tasks are not his preferred ones.

This context is increasing António's stress and makes him feeling less competent when

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> ***performing his tasks.***
>
> *[…]*
>
> *….. workCoach also supports António if the system senses that António* ***is having too much stress*** *and threatens to quit the task.*
>
> User scenario Persona 1 António

> *"Birgit takes her rest from 11.30-13.00 hours. After lunch she* ***puts on her bracelet*** *with healthyMe,*
>
> *and cycles to the office."*
>
> *[…]*
>
> *myWorkability reports that* ***she did well today*** *to cycle and by adjusting the chair and desk and that she had* ***more stress*** *when she was struggling with answering some questions.* ***Her stress level was well again*** *when she was able to talk with some colleagues from her team."*
>
> User scenario Persona 4 Birgit

Based on these user stories, the following User Needs were defined also within D2.2:

- UN_6: To monitor the stress level, alerts when it is too high and delivers advices
- UN_13 To be able to follow the performances of the team, the SW system is securely connected to the organisational management information systems
- UN_14 To be able to follow the performances of individual workers (hours spent, delivered tasks) the SW system is securely connected to the organisational management information system
- UN_15 To be able to monitor the results of the SW services on the individual team members, the services are connected to digiTeam
- UN_17 To work at home and at the office delivers the same quality of performance
- UN_22 The system reports to the individual office worker what went well during the day and where extra attention is needed to avoid stress

Although these user needs provide a starting point for the discussion of the work management interventions to reduce work related stress, a more in-depth analysis should be performed in order to elicit requirements that captures the holistic perspective of the of the SmartWork services

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3.5.4. Listed and numbered Interventions

3.5.4.1. Individual Management Interventions

Stress Management interventions at individual level aim to help employees cope better with stressful experiences. Drawing on the emotion regulation literature [115]-these techniques can be understood as promoting antecedent-focused emotion regulation strategies that seek to reduce or remove the causes of stress, or response-focused emotion regulation strategies that seek to reduce the level of stress experienced by individuals. It can also be noted that some individual-level interventions are multimodal, e.g., a combination of relaxation, cognitive behavioural therapies and mindfulness exercises. Such an approach might be used in the expectation that it will increase the likelihood of beneficial outcomes for both the individual and organization, as it can enable employees to develop a wide set of skills that can be used across different circumstances, provide employees with the opportunity to develop both antecedent and response-focused emotion regulation strategies, and increase the chance of meeting employees' needs.

TABLE 10 INTERVENTIONS FOR REDUCING WORK RELATED STRESS

Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
WMIRS_TR1	When the CSE has detected dominant concentration of mental state samples in stress state.	- "Your mental State Compass shows dominating concentrations, will you acquire a diagram plot?" - Return 0 or 1 depending user on feedback, together with *user_uuid*, and *time_of_occurance.*	-The user acknowledges the alert by "Yes" or "No"

Rationale for intervention: [116]			
Group/ID	**Name**	**Description**	**Rationale**
WMIRS_IN1	Long term stress detected. SM cannot diagnose your mental condition, but encourage you to:	The mental-state plot across time	Ongoing, chronic stress can cause or exacerbate many

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	Get to know your stress symptoms - and sharpen your attention to what are real danger signals, take these signals seriously - others may not see them. • Talk with colleagues about what stress' you. • Focus on the things you influence - and avoid as far as possible to spend energy on what you do not have an influence on. • Be aware of your workplace indeed offers help in dealing with stress. • Take your time seriously and practice prioritization, seek help from your manager. • Prioritize your relationships - both at work and at home.	shows enlarged stress level.	serious health problems.

3.5.4.2. Organisational Management Interventions

Organisational Management interventions aim to remove the causes of stress in organizations by changing organisational practices and policies, such as those concerned with leadership, working time, and occupational health and safety. The majority of primary organizational-level interventions are job redesign interventions that aim to modify job characteristics (e.g., job discretion, workload, ergonomic design) as a means of enhancing employee well-being.

Limitations to SmartWork Interventions

Individual office worker health data and other personal or sensitive data that is not known by the manager before the intervention, captured by Smartwork, must, according to D1.2. "First version of ethics and safety manual", never be accessible to managers. However, aggregated data of a group of employees, across a "longer" period, above the number of "critical mass", making the individual worker non-recognisable, is desirable for management interventions. This requires that SmartWork is able to configure groups and aggregate a number of statistical personal data records.

Memorising that the interventions are not intended for use in the diagnosis of diseases or other conditions e.g. stress, the below table interventions are advices and guides for manager interventions in case of detection of stress at group (department) level.

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TABLE 11 ORGANISATIONAL MANAGEMENT INTERVENTIONS TO REDUCE WORK-RELATED STRESS

Technical specification [117]			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
WMIRS_TR1	Manager-triggered	Provide a plot of aggregated mental states of a group of +55 years of age workers	NA

Rationale for intervention			
Group/ID	**Name**	**Description**	**Rationale**
WMIRS_IN1	• To be a credible role model as manager you have to able to relate to your own stress level. A stressed manager easily infects his employees. • Help reduce stress and contribute to it, becomes natural to talk about stress in the office. • Be responsive and avoid the fight over who's to blame for stress. • Understand how you as a manager can help a stressed employee. E.g. you help the employee prioritizing his/her tasks or reducing task pressure for a period of time • Keep of a phone number ready so you can offer stressed employees professional help if you judge it is required	The manager must show the way.	It is the management that legally is responsible for ensuring a healthy and safe work environment. In other words, it is also a management responsibility to detect and respond to hazard signals relating to stress.

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3.5.5. Relationship to SmartWork tools, training modules and services implementation

Due to the sequential planning of workpackages it is at the finalisation of this deliverable it is not evident how the Work Management Interventions will be realised. However, the interventions and triggers for intervention will be related to three work packages:

- WP4: Tools for decision support, by Data-driven modelling and AI. This functionality will identify patterns in heterogeneous data sets of daily living and working, integrating the results of the different sensing technologies and explicit user input to produce interventions.
- WP6: Work Flexibility Tools and on-Demand Training", implements the add-on modules for work flexibility functionality, training modules and new skills acquisition.
- WP7: System Integration and SmartWork Services Implementation. In WP7 the technologies implemented in WP3-6 are integrated, and the SmartWork services and interventions are implemented based on the architecture and use cases defined in WP2.

Work management interventions to reduce work related stress, are related to and realised by three of the SmartWork services to be realised in WP7:

To reach the implementation state will require corporation on definitions, functionality, trigger and combinations hence this First version of Interventions will provide guidance to the above workpackages and more interaction before realising the services.

Work management interventions to reduce stress			
SW Services	**SW Interventions**	**SW Modelling**	**SW Data**
healthyMe	Long-term psycho-physiological individual intervention	Modelling toolbox (compiling individual Emotion/Cognitive data)	Emotion/Cognitive data
digiWork	Long-term psycho-physiological intervention at group level	Modelling toolbox (aggregate Emotion / Cognitive data of a number of individuals)	Emotion/Cognitive data

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3.6. Work-related training interventions, to facilitate knowledge acquisition and intergenerational knowledge transfer

3.6.1. The knowledge transfer intervention domain

From the desk research and the survey among older workers, managers and employers (D2.2 - First version Co-creation report, 2019) the most valued feature of older employees is that they have a lot of knowledge and experience. Knowledge of the organisation, on how to perform the job at the office and how to deal with the formal and informal culture. Also, older workers possess a broad network. Older workers are seen as good coaches and also have authority based on knowledge.

The main issue regarding the interventions is to find the optimal solutions within the SmartWork system to facilitate the intergenerational knowledge transfer.

1. Before intergenerational knowledge transfer can take place, it is important to consider the following the issues [118]:
2. Differences in **work attitudes** between younger and older workers

There are stereotyping differences or facts such as:

- Live to work or work to live;
- Loyal to the employer or always looking for new job opportunities;
- Search for stability or searching for satisfaction;
- Work and private life separated versus work-life-fluency
- Interested in job promotion or not

3. Differences in **worker characteristics** between young and old

Stereotypes or facts in differences between old and young are characteristics such as:

- Digital immigrant or digital native
- Communication with email versus communication with social media
- Single tasker or multitasker
- Words versus image and sound
- Rapid or slow information consumer
- Well-developed social and communication skills versus low skills

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4. **Learning attitude** differences between young and old

Stereotyping differences and facts:

- Serious learning methods versus gamification
- Step-by-step learning versus just-in-time learning
- Slow or fast learner
- Fit for abstract theory learning versus applied learning and working

These differences, whether they are stereotypes or facts, must be taken into account before the SmartWork interventions are developed. This means that the best ways for older and younger workers to transfer and receive knowledge from the other generation must be defined within the interventions.

Next to the aforementioned intergenerational variations, the interventions on knowledge transfer are also influenced by other aspects, such as levels of education (high or lower level), personal attitudes (such as pessimistic-optimistic, eager or rather willingness/unwillingness to learn), and the variety within the older and younger age-groups (millennials, Generation X and Y). To avoid that the system will become too complex we only focus on the intergenerational facts and stereotypes.

3.6.2. Motivations for intervention

Personas references:

António learnt that he could easily activate a simpler interface for Excel, which makes his work more easy. Extra support and guidance however are still very welcome.

User scenario Persona 1 António

In this way Maria can check how her team members are performing, what their competences and needs are and in which way she can support or correct them.

User scenario Persona 3 Maria

Birgit works 32 hours per week as senior policy advisor labour affairs at the Municipality of Aarhus.

Then Birgit will have to support the alderman of Social Affairs who recently released a new policy measure on voluntary and paid work.

User scenario Persona 4 Birgit

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User needs:

Feature	User Need ID (UN_##)	User Need Description	SmartWork service
MS Office tasks	UN_3	Support and guidance to learn to handle programmes such as Excel, Word, Outlook Support and guidance to organise the work and find resources	workCoach
Digital support	UN_4	To achieve support and guidance the user can verbally ask or type the question, complaint, misunderstanding	workCoach
Information from organisational management information systems	UN_13	To be able to follow the performances of the team, the SW system is securely connected to the organisational management information systems	digiTeam
Information on individual workers' performance from management information system	UN_14	To be able to follow the performances of individual workers (hours spent, delivered tasks) the SW system is securely connected to the organisational management information system	digiTeam
Information on flexibility, workability and coaching SW services for individual workers	UN_15	To be able to monitor the results of the SW services on individual team members, the services are connected to digiTeam	digiTeam
Coaching on job performance	UN_22	The system reports to the individual office worker what went well during the day and where extra attention is needed to avoid stress	myWorkability

3.6.3. Listed and numbered Interventions

TABLE 12 INTERVENTIONS ON KNOWLEDGE TRANSFER

Rationale for intervention			
Group/ID	**Name**	**Description**	**Rationale**
WTIAT_IN1	Digital skills training	- Training from younger workers to older workers to learn digital skills	In cases in which older and younger workers work together in a team and digital skills are needed. Younger workers are very well equipped to additionally teach older workers how to use certain programmes

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			etc.
WTIAT_IN2	Working skills training	Training from older workers to younger workers on how to write policy documents, reports, financial reports, etc	In cases where younger workers are new on the job and need to learn new skills of work

Rationale for intervention – cont.			
Group/ID	**Name**	**Description**	**Rationale**
WTIAT_IN3	Networking skills training	Older workers involve younger workers in their networks and teach them how to network	In cases younger workers are new on the job and need to learn new skills on networking
WTIAT_IN4	Communication skills training	Both age-groups of workers learn from each other: how to communicate with a different kind of workers. Which method is useful in which occasion?	Both age-groups can learn from each other the best ways to communicate whenever this is needed.

Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
WTIAT_TR1	Underperformance of older worker on computer tasks	- Activates workCoach and reports to manager in digiTeam. Manager arranges younger worker for support	- Worker agrees to receive support from younger workers
WTIAT_TR2	Younger workers need support or networking skills	digiTeam reports requests or underperformances of younger workers in the team	- Manager connects workers to each other - Workers agree or disagree
WTIAT_TR3	On request of	Pairing to learn	- Agree or disagree

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	younger and older workers improvement of communication skills	communication skills from each other	

3.6.4. Relationship to SmartWork tools, training modules and services implementation

Knowledge transfer interventions			
SW Services	**SW Interventions**	**SW Modelling**	**SW Data**
myWorkability workCoach digiTeam	User state aware workability prediction Individual training Work flexibility Team pairing Work interventions	Activity My workability modelling Team pairing module On Demand training modules Training needs prioritizing module	Functional data Technology acceptance model Workability data Work task model Work data

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3.7. Work environment adaptations

3.7.1. The work environment intervention domain

Office workers usually spend a mayor part of a working day at the office. The office environment is therefore also of influence on the health of workers. This is the reason why in many European countries policy makers, labour organisations and employers pay attention to the improvement of the working environment to prevent that workers become ill or develop chronic conditions due to working conditions.

The work environment can be split into the following domains:

- Physical environment:
    - The office building, including its stairs and elevators, entrance, floors, landings, hallways, restaurant, surroundings
    - The office: the room where people work during working hours, single office rooms, shared office rooms, office gardens
    - Workers' desk and chair and the use of equipment, shared or private use

    In general, physical working environments must be safe to protect the worker from physical harms (such as accidents) and sensory damages (on ears, eyes). The air in the working environments must be clean to avoid loss of productivity or the development of pulmonary diseases or allergies. The climate temperature also influences the work productivity of the worker. To provide inclusive working environments, the environment must be accessible for people with physical impairments (using wheelchair, walker or walking stick) or with impaired vision and hearing (spoken support or written/icons/touch support).

    From literature it is known that ergonomics of the physical workstation influence the inclusion and workability[99]–[102] of older workers. For example, to provide workers with adapted chairs, adjust the height of the desk, or provide site stand tables, treadmill desk and pedal machines. It influences the muscles and skeleton of the worker to avoid pain from sitting or working in the same position at a desk. It enables people to (continue to) work in case of decreased health and skills for example to bend or sit. Also, it addresses conditions that may reduce work productivity, absenteeism and healthcare costs.
- Social environment: the formal and informal culture to work in, the manners of behaviour between managers and employees, employees among each other, eventual matters of bullying. Fair treatment, the composition of the team, salary and wages, no discrimination, interesting work are matters that positively influence the joy of work.[103]–[107]

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- Digital environment: the hard- and software the employee uses and its ways to use them. Besides the improvement of technology skills of older workers, the digital environment also delivers optional interventions for the employability of older workers. For example, the ease to login, the readability of documents on screen, the findability and trustworthiness of information influences the productivity and joy of work.
- Contractual and organisational conditions: such as flexible working hours, working schedule of daytime, evening work, workload, cognitive demands, training and learning opportunities, personal development, early retirement possibilities, gender policy and equal treatment.

3.7.2. Motivations for intervention

Personas references:

António is bored to type each time his username and password and wishes that there was another way to enter the machine. His manager asks him to perform administrative tasks in the Excel programme. He had a training on Excel and now understands the basics of it. Using Morphic to login on the shared desktop computer, he learnt that he could easily activate a simpler interface for Excel, which makes his work easier. User Scenario Persona 1 Antonio

The SmartWork system (healthyMe) monitors that he is in pain and checks the way António is sitting and at what height his desk and chair are installed. User Scenario Persona 1 Antonio

During the meeting Maria at first complimented the team members with the delivered progress. She mentions that the Chair of the Board personally congratulated her and the team on the progress that was clearly visible on the CMIS. User Scenario Persona 3 Maria

Maria saw that during the meeting the members were showing some disinterest and were hesitant to take up new challenges. User Scenario Persona 3 Maria

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Today Birgit starts to work at home, because she has a long working day ahead.

At the office some weeks ago, Birgit already set the settings she prefers to work with in her desktop computer using the Morphic Quickstrip. There, Birgit found that she is more comfortable using bigger fonts and high contrast, which she probably would have not been able to find out by herself.

Because of her late arrival, Birgit has to search on other floors for a free desk to work. The Municipality introduced the flexible office concept a couple of years ago and at some days it is very hard to easily find the right place to work. Arrived at her workplace she adjusts the desk and chair at her height and opens up her laptop again

User Scenario Persona 4 Birgit

User needs:

Feature	User Need ID (UN_##)	User Need Description	SmartWork service
Login	UN_2	Easier way to login than using username and password; ○ Touch recognition ○ Eye recognition	Devices SmartWork apps
Sitting at a desk and working at computer	UN_5	To monitor the right position to sit and work at a desk and to advise to take a rest, walk, adaptable workstation, sit-stand desk	healthyMe
Information from organisational management information systems	UN_13	To be able to follow the performance of the team, the SW system is securely connected to the organisational management information systems	digiTeam
Information on individual workers' performance from management information system	UN_14	To be able to follow the performance of individual workers (hours spent, delivered tasks) the SW system is securely connected to the organisational management information system	digiTeam
Information on flexibility, workability and coaching SW services for individual workers	UN_15	To be able to monitor the results of the SW services on individual team members, the services are connected to digiTeam	digiTeam
Informed consent and withdrawal opportunities	UN_16	digiTeam and iCare are only connected to the SW services the office worker has agreed to share. The office worker can withdraw the informed consent at any time	SW services informed consent and withdrawal security
Working at home flexibility	UN_17	To work at home and at the office delivers the same quality of performance	ubiWork

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System starts there were ended the last time	UN_18	After starting-up the system automatically returns to where the user left the session before and automatically connects to the SW apps	SW system
Secured internet at home	UN_19	The system checks whether or not the internet connection at home and at the office is secured	SW system
Place to work	UN_20	The system provides information where available desks are located	SW system
Adaptable workstation	UN_21	To be able to adjust chairs, desks, monitors at the workstation, adaptable furniture and devices are available	Organisation
Coaching on job performance	UN_22	The system reports to the individual office worker what went well during the day and where extra attention is needed to avoid stress	myWorkability

3.7.3. Listed and numbered Interventions

TABLE 13 INTERVENTIONS ON WORK ENVIRONMENT

Rationale for intervention			
Group/ID	**Name**	**Description**	**Rationale**
WEA_IN1	Best sitting position	- Workplace is accommodated or easy to accommodate according to the personal needs of the worker	- To comfort the body at work and to avoid stress and pain, the chair, desk and digital devices are adapted according to the needs of the worker
WEA_IN2	Clean air and comfortable temperature	The sensing system detects the air condition and temperature at the workplace	To provide optimal working circumstances and avoid diseases such as pulmonary disease or allergies the air and temperature at the workplace must be clean and comfortable
WEA_IN3	Optimal social working environment	Team performances and social trust within the team and the team and the manager are being monitored and brought	An optimal social environment is of influence for the workability of older workers

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		into attention of the management	
WEA_IN4	Optimal digital working environment	The worker is enabled to set his/her own preferences and needs in the working environment and these settings are automatically available on every working device	To promote the efficiency and joy of the older worker
WEA_IN5	Flexible hours and remote work availability	Workers are enabled by the organisation to work remotely at home or other safe working places and to work flexible hours under the condition of secured internet access	To foster occurring needs of flexibility
WEA_IN6	Workplace availability	Where to find a place to work in flexible working environments on late arrival at the office	To ease the finding of a workplace

Technical specification			
Group/ID	**Triggers**	**System actions**	**User actions (feedback)**
WEA_TR1	Worker reports pain	- System advises to improve the workplace by ergonomic adaptations	- Worker uses the adapted workplace equipment
WEA_TR2	System sensors unclean air or cold/warm temperature	System allows the worker to change the temperature and alarms the workers at the office in case of unclean air	Worker adapts the temperature or puts on the ventilation or opens windows
WEA_TR3	digiTeam reports underperformances and worker reports less wellbeing	digiTeam proposes to the manager to work on the social environment	Manager takes action to improve the social climate

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WEA_TR4	Personal settings on digital devices	System activates Morphic Quickstrip to unify the settings on every device the workers uses	Worker uses the personal settings
WEA_TR5	Worker indicates to need working hours or workplace flexibility	System (digiTeam) advises the management to consider this request and eventually enables the worker to more flexible or remote work. System checks the secured internet access at home	Management agrees or disagrees on request. System blocks when internet access is not secured
WEA_TR6	Late arrival at the office, worker indicates to be willing to find a suitable workplace	System indicates the available workplaces at the office	Worker makes choice which one to use

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3.7.4. Relationship to SmartWork tools and services implementation

Work environments adaptations interventions			
SW Services	**SW Interventions**	**SW Modelling**	**SW Data**
healthyMe MyWorkability workCoach ubiWork digiTeam iCare	Health interventions Short- and long-term health risks prediction User state aware workability prediction Anywhere delivery Individual training Work flexibility Work interventions	Health data Activity My workability modelling GP8 On-the-fly work flexibility management module Training needs prioritizing module	User data Functional data Technology acceptance model Needs and preferences data Workability data Work task model Work data Health history data Security and privacy

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4. Relationship of interventions and SmartWork and services

In this document interventions have been addressed by a transdisciplinary approach, to account for the multi-dimensional aspects of active and healthy ageing:

I health care interventions, for health self-management;

II behavioural interventions to promote physical activity, healthy nutrition and wellbeing;

III cognitive function interventions to maintain cognitive capacity;

IV work management interventions to reduce work related stress;

V work-related training interventions, to facilitate explicit/implicit knowledge acquisition and intergenerational knowledge transfer; and

VI work environment adaptations.

Chapter 3 is focusing on each of these domains and the domain interventions. The interventions are named and listed in the chapters. At the end of each chapter a table is established giving the envisaged relationship to SmartWork tools, training modules and services. The naming of data, models/modules

Summing the six tables and reducing duplicates, the identified SmartWork **data-structures** envisage to support the individual user by the defined interventions embrace:

TABLE 14 SUMMARY OF SMARTWORK DATA STRUCTURES

User data	Functional data	Workability data
Need & preferences profile data	Emotional data	Technology acceptance data
Work / Work task data	Health data	

Similarly, the authors to the interventions have identified SmartWork **models/modules** which by applying the individual data, should generate the interventions:

TABLE 15 SUMMARY OF SUMMARY SMARTWORK MODELS/MODULES

Activity modelling	Lifestyle modelling	Functional modelling
Psychology modelling	Emotion modelling	My workability model
Cognitive ability modelling	Team pairing module	On Demand Training module

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Training needs prioritising module	On-the-fly work flexibility management module	GP8

Distribution the six domains across the six SmartWork services results in:

TABLE 16 DISTRIBUTION OF THE INTERVENTIONS DOMAINS ACROSS SMARTWORK SERVICES

SmartworkService	Domain
healthyMe	• Health Care interventions for health self-management • Behavioural interventions to promote physical activity, sleep, healthy nutrition and wellbeing • Work environments adaptations interventions
MyWorkability	• Health Care interventions for health self-management • Behavioural interventions to promote physical activity, sleep, healthy nutrition and wellbeing • Work management interventions to reduce stress • Knowledge transfer interventions
workCoach	• Health Care interventions for health self-management • Knowledge transfer interventions • Work environments adaptations interventions
ubiWork	• Work environments adaptations interventions
digiTeam	• Knowledge transfer interventions • Work environments adaptations interventions • Work management interventions to reduce stress
iCare	• Health Care interventions for health self-management • Work environments adaptations interventions

Further study of the tables across the six domains reveals that relationship between interventions and the six SmartWork services is ambiguous and will require further scrutiny before unambiguous relations between SmartWork services, modules, tools and data-structures can be established.

However, this deliverable is considered a high-level requirements document reflecting the expectations to the SmartWork system and architecture as they are derived from D2.2 user needs and use cases.

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5. Conclusions and future elaboration on Intervention strategies

The scope of interventions addressed is comprehensive and covers the relevant domains to achieve healthy aging for the office worker. The previous project work on user needs/requirement clearly constitutes a solid base for elaboration on interventions. The intention of this deliverable, to specify 'High Level Requirements" for the SmartWork infrastructure and functionality is achieved to a significant extent.

Reading through the document it comes to mind that there are still a number of issues to be addressed for future elaboration on Interventions. The most significant ones are summarised below.

At this point in time the interventions in the document are based on the assumptions that certain functionality within the SmartWork unobtrusive sensing system detects certain events. Whether that functionality can actually be realised is an assumption which translates into requirements to the functionality of SmartWork and need for verification.

Going through the tabled interventions it becomes obvious that the user can be exposed to large amounts of man-machine communications, e.g. the Machine-Learning sessions and interactions requiring many Q&A-sessions such as establishing base-line profiles. Somehow there must be a limit to interruptions experienced by the users in order to avoid over-burdening the user and the possibility of counterproductive results.

It may be a challenge to the project to design access for employers. Recalling the user needs/requirements and ethical guidelines of the project, it is expressed that employers and managers are never to get access to individual health-data of any employee. However, access to aggregated data, where the individuals are non-recognisable, is desirable to both parties – employer and employee. How this requirement is to be realised is not addressed in the present Intervention Strategies.

Similar, the user needs and requirements are clear concerning information exchange between man and machine. The possibility of ambiguity must be minimal; hence it must be required that SmartWork communicates in the local language of the country.

The interventions have been treated separately and independently within the domains. There may be a need to establish inter-relationships across domains to establish efficiency, i.e. avoid double / triple information on health profiles already captured or derived from obtained information. Similarly, to avoid advice and guidance from one domain colliding with guidance from other domains.

The six intervention domains embrace two groups having different focuses: 1) Maintenance of Health/Cognitive abilities and, 2) Knowledge-Training/Transfer and environmental elements. It may be beneficial to the project to deal separately with the two groupings. Analysing the user requirements collected at the two planned pilot-trial sites, users/managers at each site have quite

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different attitudes to the Knowledge-Training/Transfer interventions. One pilot-site users find this functionality not useful or desirable. Against this background, it may be advantageous to the project being able to omit Knowledge-Training/Transfer interventions at one site and spend the effort on Health/Cognitive abilities of the office workers.

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7. Annexes

TABLE 17 SUMMARY OF USER NEEDS

Feature	User Need ID (UN_##)	User Need Description	SmartWork service
Devices	UN_1	Desktop, laptop, smartphone, bracelet, watch to use the healthyMe service at home, at the office and on the move	healthyMe
Login	UN_2	Easier way to login than using user name and password; ○ Touch recognition ○ Eye recognition	Devices SmartWork apps
MS Office tasks	UN_3	Support and guidance to learn to handle programmes such as Excel, Word, Outlook Support and guidance to organise the work and find resources	workCoach
Digital support	UN_4	To achieve support and guidance the user can verbally ask or type the question, complaint, misunderstanding	workCoach
Sitting at a desk and working at computer	UN_5	To monitor the right position to sit and work at a desk and to advise to take a rest, walk, adaptable workstation, sit-stand desk	healthyMe
Stress and blood tension	UN_6	To monitor the stress level, alerts when it is too high and delivers advices	healthyMe
Healthy eating	UN_7	To monitor the daily food consumption. Advise on quantity, quality and health	healthyMe
Physical activity	UN_8	To monitor the distances of walking, gymnastics and other physical activity and to advise	healthyMe
Caregiving	UN_9	Reports on the health monitoring of the involved office worker. Alerts if the health status drops dramatically	iCare
Smartphone caregiver	UN_10	App to receive and follow status reports on health and wellbeing	iCare
Alert	UN_11	Bleep or sound to alert the caregiver	iCare
Smartphone and computer manager	UN_12	App that is compatible between different devices of work	digiTeam
Information from organisational management information systems	UN_13	To be able to follow the performances of the team, the SW system is securely connected to the organisational management information systems	digiTeam
Information on individual workers' performance from management	UN_14	To be able to follow the performances of individual workers (hours spent, delivered tasks) the SW system is securely connected to the organisational management	digiTeam

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information system		information system	
Information on flexibility, workability and coaching SW services for individual workers	UN_15	To be able to monitor the results of the SW services on individual team members, the services are connected to digiTeam	digiTeam
Informed consent and withdrawal opportunities	UN_16	digiTeam and iCare are only connected to the SW services the office worker has agreed to share. The office worker can withdraw the informed consent at any time	SW services informed consent and withdrawal security
Working at home flexibility	UN_17	To work at home and at the office delivers the same quality of performance	ubiWork
System starts there were ended the last time	UN_18	After starting-up the system automatically returns to where the user left the session before and automatically connects to the SW apps	SW system
Secured internet at home	UN_19	The system checks whether or not the internet connection at home and at the office is secured	SW system
Place to work	UN_20	The system provides information where available desks are located	SW system
Adaptable workstation	UN_21	To be able to adjust chairs, desks, monitors at the workstation, adaptable furniture and devices are available	Organisation
Coaching on job performance	UN_22	The system reports to the individual office worker what went well during the day and where extra attention is needed to avoid stress	myWorkability

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