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Artificial intelligence, robotisation and the work environment

Literature review 2022:1

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Preface

It is no longer news that society in general, and working life in particular, has fundamentally changed due to intensive digitalisation, increased use of robots and the development of artificial intelligence (AI). The question now is what we know about the impact of these changes on the work environment for various professional groups and for people of different genders and ages. What does it mean when your "closest colleague" is a robot? How do we experience our daily interaction with AI in our workplaces? To find answers to these and a number of other questions in existing research, the Swedish Agency for Work Environment Expertise in early 2020 initiated this literature review on artificial intelligence, robotisation and the work environment.

However, the literature review shows that it is difficult to survey and present the consequences for the work environment of changes that happen when artificial intelligence and robotisation are introduced. There is also a lag in the production of scientific studies, possibly because it takes time before the effects of change processes are noticed, determined, and evaluated. Nevertheless, this literature review illustrates the impact that the introduction of AI and robotisation may have on the work environment through a discussion of this in the context of the overall impact that the introduction of new technology has been shown to have on the work environment. The effects may be positive or negative, depending on other factors in the relevant work environment. Furthermore, the literature review identifies a number of areas in which the introduction of new technology, and consequently of AI and robotisation, influences people's working conditions and work environment, describes the changes that take place, and provides practical assistance for preventive intervention. The literature review illustrates the importance of ensuring that the implications and consequences of introducing AI and robotisation are transparent and comprehensible, so that the people who work with these "new" technologies can understand and explain them.

The authors of the literature review are Professor Åsa Cajander at Uppsala University, Professor emeritus Bengt Sandblad at Uppsala University, Magdalena Stadin, PhD, at Uppsala University, and Professor Elena

Raviola at the University of Gothenburg. Professor Magnus Svartengren at Uppsala University has reviewed the quality of the literature review on behalf of the agency. Librarians Lina Ahlgren and Hanna Dahlin at Lund University assisted the authors during the search process. The responsible process managers at the Swedish Agency for Work Environment Expertise were Monica Kaltenbrunner, PhD, and Associate Professor Robert Ljung.

The authors of the literature review have selected the theoretical and methodological approaches and are responsible for the results and conclusions presented here.

I want to thank our external researchers and quality reviewers as well as employees at the Agency who have contributed to the production of this valuable literature review.

The literature review is published on the Agency's website and in the Literature Review series.

Gävle, January 2022

Nader Ahmadi,
Director General

Summary

Digitalisation, automatisation, globalisation, deregulation, new business models and organisational forms create a new situation for companies, organisations, and businesses. Technological development also creates new conditions for jobs and has an impact on the work environment. Research, development, and the use of artificial intelligence (AI) and robotisation have picked up speed after a long prehistory. Enormous resources have been invested nationally and internationally. We are likely facing a new technological era which will affect everything and everyone, with wide-ranging consequences for individuals, jobs, organisations, and society at large. Knowledge of how technology impacts people's working conditions and work environment is important, both to understand the changes that are taking place and to be able to work preventively. By taking account of aspects of the work environment already when planning, developing, and introducing work-related technology, it is possible to design new jobs that combine efficiency, safety, job satisfaction, health, and sustainability. This requires that awareness of potential problems, their origins, and how they can be detected and prevented is available and intelligible to players and stakeholders in the process of change. It is not enough that knowledge exists in the form of scientific articles; it must also be made intelligible and applicable for practitioners. This literature review has been developed on the basis of scientific methodology, with literature searches conducted in relevant databases and information collected from other sources critically reviewed. The process had two parts. First, a systematic literature search of databases of scientific publications was carried out. Second, other knowledge, relevant to the issues and challenges of Swedish working life, was surveyed, primarily on the basis of knowledge from earlier research as well as material gathered from government agencies, organisations, and research groups in Sweden.

The literature search applied three perspectives on the work environment:

- individual
- organisational, and
- structural.

The searches were limited to publications from the last 10 years. An overall conclusion is that there is a limited amount of research on AI and robotisation that directly addresses work environment issues. However, there is some research that addresses questions that are relevant to the work environment, even if the publications do not specifically interpret the results in these terms.

There is research on the impact of AI on different professional groups, showing that for some professional groups learning job tasks and developing skills became faster and more efficient, while other professional groups tend instead to see their skills degraded. While the results of this research

are not uniform, they do indicate the importance of skills development and professional experience if automatisation and AI are to serve as well-functioning support instead of being a threat to employees' professional role. Automatisation and the use of AI systems can lead to increased efficiency for some tasks, but reduce it in other cases.

Some research studies cover automatisation and decision-making. In this area, the findings are that systems designed to strengthen rather than replace human intelligence will lead to better decisions. The research indicates that in decision-making situations the transparency of the technology is important for the relationship and interaction between people and technology. Trust is another important component and is important for the perception of privacy and how it can be ensured. Research also shows that questions related to organisational culture and leadership are important for successful implementation. Acceptance of new technology can vary significantly within and between different industries and professions, depending on how people perceive possible loss of status as well as on society's view of professional roles and the future of the jobs.

When AI systems or robots give decision recommendations intended to provide support for humans, this can sometimes lead to a lack of clarity and to security risks. Transparency is therefore important so that the human is able to understand the basis for the recommended decisions and how they can/should be interpreted and used.

Applications of AI and robotics at work bring up many ethical questions that are important to handle in order to prevent work environment problems. Among other things, this involves the consequences of discrimination against individuals or groups arising due to bias, a systematic distortion, in fundamental data and models for machine learning. The matter of responsibility is also important to clarify, legally and ethically.

The impact on the work environment that may result from the introduction of AI and robotic systems is in many respects not different from what has long been studied in conjunction with more traditional digitalisation and automatisation processes. Thus, there is reason to take stock and apply existing relevant research that more specifically addresses work environment aspects. Examples of this kind of applicable knowledge and research include topics such as the digital work environment, various aspects of automatisation in working life, Human–Technology–Organisation (HTO), the importance of a socio-technical perspective, as well as matters of resilience in such systems.

The latter part of the literature review surveys current Swedish research on AI and robotisation, as well as the strategies, directives, and initiatives currently existing in the EU and in different government agencies and organisations in Sweden. In terms of current Swedish research, we can conclude that very few programs and projects concretely address the impact on the work

environment in their studies. Government agencies, social partners, and other stakeholders show significant engagement in the application of the new technology, but adopt very few concrete measures that may have an effect on the resulting work environment. However, many highlight the need to regard AI and robotisation as a working life and work environment issue.

An overall assessment of the current state of knowledge concerning the impact of AI and robotisation on the work environment is that there is very little specifically applicable knowledge. A considerable amount of research on aspects of AI and robotisation has indirect significance for the work environment. However, there is an obvious lack of practically useful knowledge that could serve as a basis for guidelines. It is important to fill the identified knowledge gaps in order to leverage the full potential of the new technology and prevent future work environment problems. Many measures need to be taken and different players have responsibility.

The literature review concludes with some brief recommendations for how one could and should act when introducing AI and robotic systems to a business or organisation. These recommendations are based not on new research on AI, robotisation and the work environment, which is almost entirely absent, but rather on earlier research and experience that has been assessed as relevant in this area as well.

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Part 3 – Other sources of knowledge

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Appendices

1. Introduction – the assignment and the contents of the report

Technological development has always had a significant impact on the structure of working life and on the work environment. Digitalisation and automatisation have been changing the conditions of most industries and professions for decades, sometimes for the purpose of supporting people, and in other cases, to replace work tasks with automatic systems. The development and implementation of new technological solutions, such as artificial intelligence (AI), machine learning and robotisation, are happening faster and faster, and often entail extensive changes to how work tasks are carried out and how the work environment is designed. In light of this, the Swedish Agency for Work Environment Expertise has decided to produce a literature review focused on how the work environment is affected by the introduction of AI and robotisation in different industries and for different professional groups. The literature review will describe the research results and current state of knowledge pertaining to the effects of AI, machine learning and robotisation on the work environment, and contribute to the promotion of a good work environment for various jobs where the new technology may be introduced.

The literature review has been developed on the basis of scientific methodology, with literature searches conducted in relevant databases and information from other sources critically reviewed.

In accordance with the assignment, and after consultation with the project manager at the Swedish Agency for Work Environment Expertise, the project was carried out as two sub-studies:

- A systematic literature search in scientific publication databases. The purpose was to survey scientific research in the area, which had been published in the past decade.
- A survey of other knowledge in the area, relevant to the issues and challenges in Swedish working life. This primarily involves knowledge from earlier research, as well as material gathered from government agencies, organisations, and research groups in Sweden.

  One consistent ambition was to make the literature review accessible to different stakeholders so that future efforts to promote a good work environment can be supported in practice. The results are discussed from an overall perspective, among other reasons in order to be able to identify knowledge gaps and future research needs.

The literature review consists of four parts.

Part 1. Background. Artificial intelligence and robotisation in working life. Current laws and regulations. Definitions.

Part 2. The systematic literature search of published research and results.

Part 3. Description of relevant earlier research on digitalisation and automatisation, and their impact on the work environment. Description of national guidelines, governing documents and reports, current research programs as well as initiatives from government agencies, social partners, and other stakeholders.

Part 4. Conclusions and discussion regarding the current state of knowledge, as well as identified knowledge gaps and how to fill them. Recommendations for the practical application of knowledge about the design, development, and implementation of digital systems.

Part 1
– Background

Part 1 contains a background, a discussion of the transformation of working life as a result of technological developments in AI and robotisation, a review of applicable laws and regulations, as well as a number of definitions.

2. Introduction

2.1. The transformation of working life and the new technologies

Many societal changes are currently taking place at a rapid pace. New technologies, digitalisation, automatisation, globalisation, deregulation, new business models, organisational forms, increased competition, and elevated efficiency requirements are changing working conditions and creating new circumstances for organisations, businesses, and individuals.The changes are creating new opportunities as well as new challenges and problems for organisations, companies, employees, and citisens.

Changes related to new computer technology, digitalisation and automatisation are also nothing new. The first computers entered the workplace already in the late 1950s[1], but it was a long time before they became work tools for ordinary users (Lundin, P., 2009). Today, and to an ever-increasing extent, most jobs are carried out with the help of digital systems – tools that are based on digital technology. Automatic systems – either autonomous or as support to human operators – are also common in most sectors of working life. Sophisticated new technology creates additional opportunities for propelling automatisation even further. In this area, the use of artificial intelligence, AI, as well as automatisation through the use of robots of various kinds will likely produce extensive effects and changes that will impact many different aspects of working life (Godhe & Bodén, 2020).

2.2. What are artificial intelligence, automatisation, and robotisation?

After a long prehistory of mixed successes and setbacks, research, development, and the use of AI have gained speed. Significant sums have been invested nationally and internationally. We are likely facing a new technological era which will impact everything and everyone, with extensive consequences for individuals, jobs, organisations, and society.

AI is really nothing new. Research and development have been underway for several decades, and the line between new AI technology and more traditional automatisation or algorithm-controlled systems is not entirely clear. Already now, AI systems are used in working life and in society in general, but new technology for algorithm design, machine learning and the use of large data

1 https://www.tekniskamuseet.se/samlingar/forskning/fran-matematikmaskin-till-it/

sets is creating new possibilities. Artificial intelligence can be seen as a "programmed intelligence", characterised by self-learning. This is not one uniform technology, but rather a collection of different kinds of technologies. Machine learning involves a programming technology that aims to give computers the conditions to discover and learn rules to solve a task, based on available data sets and without a predetermined logical structure.

A robot is a programmed machine that can carry out a complex series of automated tasks. Sometimes a robot is integrated with AI, but that is not required for a machine to be classified as a robot. However, it is becoming more common for different kinds of AI and robotics to be integrated with one another. Robotisation of work tasks has long been a method for automatisation in companies and working life. Today we see extensive development and use of robots, both of a traditional variety, and new types based to some extent on AI technology. The increase within traditional robotisation involves, for example, applications in the manufacturing industry, medical care, vehicles, and transport. The increase within new areas is a question of more or less autonomous systems for different sectors, for information management, evaluations, case management, or for decisions and actions that previously required human actors.

Another term used today is *robotic process automation*, RPA, which involves automating (robotising) specific workflows, especially repetitive ones. In the case of automatisation of labor-intensive procedures, significant time can be saved and the benefits are high. As long as nothing unexpected happens, automatisation can also result in increased quality and efficiency. However, a human player or operator is often required to monitor and intervene as needed.

2.3. The relationship to the work environment

Naturally, all of the changes discussed above have a profound impact on affected jobs, workers and their work environments. It is important to emphasise that the work environment is what a person *experiences* at work, and is an effect of the *total* situation, the work conditions, demands, the physical and technical environment as well as social support. Talking about the work environment relative to individual technical support systems is not meaningful; rather, it must always be related to the *whole*, to the entirety of an employee's surroundings. For an individual, the technology used to develop the technical support is usually less interesting; rather, what is meaningful is how it is perceived and how it impacts the conditions and circumstances for carrying out work.

Knowledge of how the technology impacts work conditions and the work environment is important, both to understand the changes taking place and to prevent problems. The latter is perhaps most important. By taking account of aspects of the work environment already when planning, developing, and introducing work-related technology, it is possible to design new jobs that combine efficiency, safety, job satisfaction, health, and sustainability. This requires that awareness of potential problems, their origins, and how they can be detected and prevented is available and intelligible to players and stakeholders in the process of change.. It is not enough that knowledge exists in the form of scientific articles; it must also be made intelligible and applicable for practitioners.

The World Health Organisation defines the work environment as:

> *"... a comprehensive term for biological, medical, physiological, psychological, social, and technical factors that affect the individual in the work situation or workplace."*

There are several different ways of categorising and grouping aspects of and problems in the work environment. The following method is useful for analysing the effects on the work environment of the introduction of digital aids, AI and robotisation, and it is also linked to existing laws and regulations:

- Physical work environment or ergonomics
- Organisational and social work environment
- Cognitive work environment

For an understanding of the causes of work environment problems, as well as issues of responsibility and opportunities for correcting problems, it could be fruitful to identify the following perspectives, which will be explained later:

- The individual perspective
- The organisational perspective
- The structural perspective

2.4. The risk of discrimination

Artificial intelligence and robotisation affect and will affect jobs and people. It is therefore especially important to ensure that the new technology does not increase problems of discrimination at work. Applications in AI are based on processing large quantities of collected data. There may be a risk that discrimination through bias, a systematic distortion, in these data is automatically and non-transparently built into automated systems. One example of this within health and medical care, could be that medically unjustified variations in the treatment people receive, that are based on ethnicity, gender or disability, risk becoming part of an automatic system. Other risks include robot technology reinforcing

ideas surrounding legal gender, for example, through virtual assistants and helper robots being presented as "female". Other examples of discrimination can be found in systems for facial recognition, where the technology has often been developed based on whiteness as a norm, and they therefore sometimes fail to work for everyone.

2.5. The importance of a preventive perspective

Adopting a preventive approach to work environment problems linked to digitalisation and automatisation offers major advantages. The alternative would be to discover and correct problems only after they have occurred. A few important arguments for a preventive perspective are:

- It is significantly cheaper to do things right from the start. Making more extensive changes to digital systems retroactively is usually much more expensive.
- Experience shows that if digital systems are not designed to produce effective and sustainable work from the start, the problems tend to linger for a long time, possibly throughout the lifetime of the system.
- Working with systems that create a bad work environment has a number of different negative consequences, such as ineffective work, and risks to the business and to the health of employees.
- Creating a bad work environment linked to digitalisation and automatisation leads to poor acceptance and a negative attitude toward technological changes.

A few sources of information on how to work preventively are Prevent's online service "Införrättit" *["Introduce-right-IT"]*[2] as well as the books *Digitaliseringen och arbetsmiljön [Digitalisation and the Work Environment]* by Sandblad et al.; *Den (o)mänskliga faktorn [The (In)human Factor]* by Kecklund and Sandblad; and *Användarcentrerad systemdesign [User-centered System Design]* by Gulliksen and Göransson (see the reference list).

2.6. Laws, regulations, directives, and standards

This section is divided into Swedish legislation, national directives and standards, and European directives and programs.

2.6.1. Swedish legislation

When it comes to the work environment in Sweden, the fundamental regulatory structure can be found in the Swedish Work Environment Act

2 https://www2.prevent.se/infor-ratt-it/

(AML) and the regulations (AFS) published by the Swedish Work Environment Authority. The AML says, among other things, that work should provide:

> *"... opportunities for variety, social contact, and cooperation, as well as coherence between different tasks. Furthermore, efforts must be made to ensure that working conditions provide opportunities for personal and professional development, as well as for independence and professional responsibility."*

A number of regulations clarify rules and responsibility in different respects, for example regarding the physical work environment or ergonomics (AFS 2012:02), the organisational and social work environment (AFS 2015:4), as well as "work with display screen equipment" (AFS 1998:05). The digital work environment as a whole is described in the Swedish Work Environment Authority's report *Digital arbetsmiljö [Digital Work Environment]* (Gulliksen et al., 2015).

Neither the relevant legislation nor the regulations contain any aspects explicitly pertaining to AI, robotisation or the work environment.

2.6.2. National directives and strategies

Among the relevant national guidelines are the Government Offices' document *National approach to artificial intelligence* (Ministry of Enterprise and Innovation, 2018) as well as the government communication 2020/21:92 *A good work environment for the future – the Government's work environment strategy 2021–2025* (Ministry of Employment, 2020).

The document on a national approach to artificial intelligence says, among other things, the following:

> *"[...] the Government's goal is to make Sweden a leader in harnessing the opportunities that the use of AI can offer, with the aim of strengthening Sweden's welfare and competitiveness. [...] It is important that Sweden can manage the challenges associated with AI. AI will affect how people work, when some tasks can be automated, and new tasks emerge. There may be unintended or unforeseen consequences of using AI as a result of biased or manipulated data, lack of transparency, misuse, or hostile use. This may lead to discrimination, loss of trust, financial damage, and consequences for the functioning of democracy. For these reasons, it is important for Sweden to work actively on the issues that AI is already raising"* (p. 5).

And:
"The Government's assessment is that:

- *Sweden needs to develop rules, standards, norms, and ethical principles to guide ethical and sustainable AI and the use of AI.*
- *Sweden needs to push for Swedish and international standards and regulations that promote the use of AI and prevent risks.*
- *Sweden needs to continuously review the need for digital infrastructure to harness the opportunities that AI can provide.*
- *Sweden needs to continue the work on making data available to serve as infrastructure for AI use in areas where it adds value.*
- *Sweden needs to continue to play an active role in the EU's efforts to promote digitisation and reap the benefits that the use of AI can bring"* (p. 10).

In its communication on the work environment strategy for 2021–2025, the Government points out that globalisation and rapid technological development are leading to comprehensive structural changes in the economy and the labor market, and that the increase in digitalisation, robotisation, and the use of artificial intelligence is pushing these changes at a rapid pace. This means that some jobs are disappearing and being replaced by new ones that often have a better physical work environment. But one can also conclude that certain jobs that were previously physically demanding have now become more cognitively demanding instead, which has an impact on the digital work environment. Issues concerning the cognitive and digital work environment therefore need to be clarified in the management of the work environment and the Government is eager for the work environment agencies actively to tackle these issues.

2.6.3. European directives and programs

In recent years, a number of different reports and guidelines have been developed in the EU, resulting in 2021 in a proposal for a brand-new AI regulation.

In December 2018, the first coordinated AI plan was presented as a common undertaking for member countries. An overall picture of the EU's AI strategies can be found in "A European approach to artificial intelligence."[3]

The EU document *Ethics Guidelines for Trustworthy AI* (EU, independent expert group, 2019) presents ethics guidelines for trustworthy AI. In 2020, the European Commission published its forward-looking white paper on AI, *On Artificial Intelligence – A European approach to excellence and trust* (European Commission, 2020). The vision for AI in Europe is presented already in its title: "an ecosystem of excellence and trust". The white paper was followed by a report on the consequences for safety and liability of AI, the Internet of Things and robotics, which identified gaps in the current product-safety legislation that must be corrected.[4]

3 https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence
4 https://op.europa.eu/sv/publication-detail/-/publication/4ce205b8-53d2-11ea-aece-01aa75ed71a1/language-sv/for- mat-PDF

Finally, in April 2021 a proposal for a new EU regulation was presented: *Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts* (European Commission, 2021). Among other things, it says that:

> *"The purpose of the proposal is to harmonise rules for AI within the EU, to strengthen the competitiveness and function of the internal market and to avoid fragmentation of the internal market, to protect health, safety and fundamental rights, to promote the positive aspects of AI and to ensure free movement of AI systems."*

In a supplement to the proposal: Coordinated Plan on Artificial Intelligence 2021 Review. Fostering a European Approach to Artificial Intelligence, there are a few references connected to work environment issues.[5] For example:

> *"Robots will be increasingly autonomous and interacting with humans, be it co-working robots emerging from cages or robots providing services. This raises questions of safety: proximity to humans and interaction with them requires very high safety standards to prevent accidents and injuries. It also raises issues regarding ensuring accessibility and inclusiveness of persons with disabilities."*

In the proposal for a new AI regulation, a risk-based method is used in which rules for applications at different risk levels are to be identified. This involves regulating different types of applications related to risks linked to trustworthiness, safety, and citisens' rights. The levels of risk are defined as unacceptable, high, limited, and minimal. Artificial intelligence at an unacceptable level is to be prohibited; a high level is to be controlled by strict obligations; at a limited level, special transparency requirements apply, and low-level AI may be freely applied.

There are no further direct links to work environment issues in the various documents and reports, or in the proposal for a new EU regulation. All guidelines and concrete proposals for regulations are formulated at a more general level and address the technology's applications and transparency, and citisens' safety, trust, and privacy. There is some wording connected to work environment issues, but at a fairly general level.

It is up to each member country to translate the general guidelines in the regulations to a more operational level. A report from the European Agency for Safety and Health at Work, *OSH and the Future of Work: Benefits and risks of artificial intelligence tools in workplaces* (EUOSHA, 2019) says:

5 https://digital-strategy.ec.europa.eu/en/library/coordinated-plan-artificial-intelligence-2021-review

"Although there are significant possibilities for workplace progress and growth in productivity, there are also important OSH safety and health-related questions arising as AI is integrated into workplaces. Stress, discrimination, heightened precariousness, musculoskeletal disorders, and the possibilities of work intensification and job losses have already been shown to pose psychosocial risks, including physical violence in digitalised workplaces. These risks are exacerbated when AI augments already existing technological tools [...] Indeed, AI exaggerates OSH risks in digitalised workplaces, because it can allow increased monitoring and tracking and thus may lead to micro-management, which [is] a prime cause of stress and anxiety. [...] But it is worth stressing that it is not technology in isolation that creates OSH benefits or risks. It is instead the implementation of technologies that creates negative or positive conditions."

The report also discusses a number of different work environment risks that can be expected to increase when the use of AI systems and robots increases. The main reference provided for the discussion of work environment risks is *The threat of physical and psychosocial violence and harassment in digitalised work* (Moore, 2018).

A policy document from the European Agency for Safety and Health at Work, *Impact of artificial intelligence on occupational safety and health* (OSHA, 2021), states that AI creates new possibilities, as well as new challenges for the work environment. The conclusion is that much of the discussion to date has been about whether jobs are disappearing or being created, but that it should be equally important to discuss the quality of jobs and that work environment aspects are important in this context.

3. Definitions

Many of the terms used in this literature review have established definitions, while others lack clear definitions. The terms are also used differently and with different delimitations in scientific publications, and the meaning of some terms differs between Swedish and English. The definitions used for the terms in this report are given below.

3.1. Digitalisation, usability, and automatisation

Digitisation/Digitalisation
Digitisation and digitalisation have two different meanings. Digitisation refers to the process in which analogue information is turned into digital information. This means the information can be structured and searched and is available through digital channels. Digitalisation is the change to society, working life, businesses, technology use and the new business conditions arising through the new possibilities provided by technology. Digitalisation can occur through different kinds of digital technology: more traditional computer technology, information and communication technology, or more advanced technology such as AI and robots.

In this report, we have chosen to define digitalisation in accordance with the national Digitalisation Commission, which stated the following in 2014[6]:

> *"Digitalisation is the process of transforming humans and society that is gradually becoming increasingly difficult to keep separate from any part of life. It means that individuals and organisations can communicate and exchange information with other people, organisations, and their surroundings in brand-new ways. Digitalisation and the use of IT-based solutions can contribute to increased accessibility and efficiency within companies as well as public administration."*

Digital skills
Digital skills have been defined in Government reports as follows[7]:

> *"The extent to which one is familiar with digital tools and services and has the ability to follow digital development and its impact on one's work and life. Digital skills include the ability to search for information, communicate, interact and produce digitally, skills using digital tools and services, and understanding of the societal transformation entailed by digitalisation, with its opportunities and risks, as well as motivation to participate in the development."*

6 https://www.riksdagen.se/sv/dokument-lagar/dokument/statens-offentliga-utredningar/for-digitalisering-i-tiden_H4B389/html
7 https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2015/03/sou-201528/

Usability
We have chosen the definition of usability given by the Swedish Institute for Standards:

> *"The extent to which a product can be used by specific users to achieve specific goals effectively, suitably and satisfactorily in a specific context of use."* (Source: SIS 2018)

Accessibility
Accessibility involves the possibility of people with various disabilities or functional variations participating in working life on good or equal conditions. Accessibility is defined according to a Swedish standard as:

> *"The extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use."*
> (Source: ISO 26800)

Automatisation
Automation or automatisation involves a machine carrying out work. The machine can carry out work entirely on its own or in interaction with a person, an operator. Previously, automation primarily involved physical activities. Now, and even more in the future, it also involves cognitive activities.

Human–Technology–Organisation
Human–Technology–Organisation (HTO) is a general collective term referring to approaches, knowledge, and use of different methods for analysis and design of the interaction between humans, technology, and organisations. The concept is a systems approach that emphasises interaction and dependence between the three components, H, T and O.

Safety culture
Safety culture comprises those shared attitudes, values, assumptions, and patterns of action among individuals in an organisation that pay attention to the importance of health and safety as well as to the need for appropriate control.

Information and communication technology (ICT) demands
Information and communication technology (ICT) demands describe the new or changed demands on employees, both structural and as experienced, that have direct consequences on their health and well-being and that arise through the use of digital technology.

3.2. Work environment

Physical work environment, ergonomics
The organisation Ergonomi och Human Factors Sällskapet Sverige (EHSS)

("Ergonomics and Human Factors Association Sweden") defines ergonomics as follows[8]:

> *"Ergonomics is an interdisciplinary research and application area that, from an overall perspective, addresses the Human–Technology–Organisation (HTO) interplay for the purpose of optimising health and well-being as well as performance when designing products and work systems."*

In this report, we use ergonomics to refer primarily to the physical work environment.

Organisational and social work environment
The Swedish Work Environment Authority defines the organisational work environment as the conditions and prerequisites for work that include management and governance, communication, participation, room for action, allocation of work tasks, as well as demands, resources, and responsibilities. According to the same regulation, the social work environment is defined as the conditions and prerequisites for work that include social interaction, collaboration, and social support from managers and colleagues. (Source: AFS 2015:4)

Cognitive work environment problems
Problems arising when conditions in the work situation prevent an individual from utilising their cognitive ability (knowledge and skills) to carry out work tasks safely and effectively. Such characteristics could be a bad work organisation, or a user interface with inadequate usability.

Digital work environment
The work environment, with its physical, organisational, social, and cognitive problems and opportunities, which results from the digitalisation of work support systems and tools.

Work conditions during AI and robot assisted work
The work environment, with its physical, organisational, social, and cognitive problems and opportunities, which results from work being replaced, supported, or supplemented by AI systems or robots.

3.3. Artificial intelligence and robotisation

Artificial intelligence
Artificial intelligence (AI) is an imprecise term that is used in different contexts and with varying scope and meaning. A basic definition is that it involves a programmed machine demonstrating intelligent behavior, in other words,

8 https://ehss.se/

a non-biological intelligence. To the question of what is meant by intelligence, there is also no clear answer. Among other things, it involves the ability to achieve complex goals independently. In this way, AI largely involves an advanced form of automatisation, primarily with the help of self-learning algorithms.

AI is also an academic discipline that mainly studies how to develop computers and computer programs, algorithms, which demonstrate intelligent behavior. The purpose is to create intelligent agents, in other words computer systems that perceive their own surroundings and can act more or less independently to achieve a certain goal. There are many applications, usually involving the creation of increasingly sophisticated automatic systems, for example in industry, the service sector, medical care, and administration. Research and development in AI is usually interdisciplinary and linked to computer science, robotics (see below), machine learning, mathematics, psychology, linguistics, neuroscience, and philosophy.

Creating artificial general intelligence, in other words a system that, entirely on its own, shows at least the same capacity for intelligence or intelligent behavior as a human, including the ability to develop its own intelligence, is a long-term goal for many AI researchers.

Robot
A robot is a programmed machine that, autonomously or controlled by an operator, can carry out a complex series of automated tasks. A robot can be integrated with AI, but this is not a requirement for the machine to be classified as a robot. In this literature review we want to differentiate between more traditional robotisation, with older technology, and a more modern form. A robot does not have to be the shape of a machine, for example an industrial robot, or have a human-like appearance, a humanoid. A robot can be in the form of software that more or less independently gathers information, interprets it, manages cases, makes decisions, and carries them out and so on. A traditional industrial robot is not aware of its surroundings and cannot adapt to new situations; rather, it only carries out pre-programmed movement patterns. Such robots are not included in this study. Searches and analysis have targeted robots that are in some way aware of their surroundings and that can adapt their behavior to what is happening.

Robotics
Robotics is the science of, and technology for, the design, construction, application, and use of robots, as well as the systems required for their control, governance, feedback from sensors, and information processing.

Robotisation
Robotisation entails the transfer of work from a human to a robot, in other words, that a robot fully or partly takes over tasks that were previously handled by a human. This can also refer to automatisation of a process with the help of a robot.

Part 2
– Research literature

Part two contains a literature review and analysis based on the systematic literature search. It is divided into three parts:

- The individual perspective
- The organisational perspective
- The structural perspective

4. Introduction, the different perspectives

The purpose of the literature review is to survey and describe research that studies how AI and robotisation affect the work environment based on three different perspectives:

The individual perspective
The impact of AI and robotisation on individuals directly, in their daily work, on work conditions and circumstances in terms of workload, difficulties, challenges, opportunities, health, and well-being.

The organisational perspective
The impact of AI and robotisation on organisational work environment aspects such as decision-making, power, leadership, social support, organisational and safety culture, education, and change processes.

The structural perspective
The impact of AI and robotisation on structural factors and change processes that may affect the work environment in terms of laws and regulations, technological development, system development, system implementation as well as the media's portrayal of AI and its consequences for work.

We also explored whether the research contained an equal opportunities perspective.

- constitutes a suitable structure that corresponds with how the relevant research is normally conducted and published
- clarifies the causes of work environment problems
- clarifies responsibility for and opportunities to correct existing problems.

The division of the work environment into physical, organisational, social, and cognitive aspects (which is presented in chapters 5 and 6) relates to the first two perspectives. The structural perspective is needed to describe changes at the societal level that impact individuals' working conditions and how they experience their work.

5. 5. Literature search methodology

5.1. Methods and search strategies

This part of the literature review is based on analyses of scientific literature in the form of peer-reviewed journal articles. The study design for the systematic research literature review is in the form of a scoping review, in accordance with the Swedish Agency for Work Environment Expertise's literature review model. This study design was chosen because it facilitates a broad overview of one or more research questions without being limited to only including articles of a certain type. The literature searches were carried out separately for each perspective (individual, organisational and structural), and the search templates for each database and perspective can be found in the appendices (see chapter 13).

5.2. Inclusion and exclusion criteria

The inclusion and exclusion criteria were developed in accordance with the Swedish Agency for Work Environment Expertise's analysis model, PEO: P – Population; E – exposure; O – outcome, see table 1. The PEO model is particularly suitable for analyses of qualitative questions.

Table 1. Inclusion and exclusion criteria in accordance with the PEO model

	Inclusion criteria	Exclusion criteria
Population	Employed individuals	Non-primarily employed individuals, such as students, housework, non-profit work, patients, relatives, car drivers
Exposure	AI and robotics at work Attitudes toward AI and robotics at work	Research that is not connected to the work environment and working conditions
Outcome	Work environment factors from an organisational, social, cognitive, or physical perspective Expertise and decision-making. Ethics, norms, and discrimination. Structural changes to work	Research pertaining primari-ly to the technical aspect of AI and robotics, but that does not study work envi-ronment factors Studies analysing the impact of AI and robotics without being linked to the recipi-ent's professional role (pa-tients, clients etc.)

5.3. Implementation

The purpose, research area and inclusion and exclusion criteria were developed before the actual literature review was conducted. Search templates were developed in consultation with librarians at Lund University. The design of the search templates was based on pre-understanding as well as suggestions for various areas and questions describing each perspective.

The formulation of search terms for the individual perspective targeted AI and robotics in relation to:

- professional skills, competence, and sense of meaningfulness
- autonomy and trust in technology
- different types of work-related stress, such as technostress
- ergonomic aspects of the work environment
- cognitive work environment
- risks and safety from a work environment perspective.

The formulation of search terms for the organisational perspective targeted AI and robotics in relation to:

- management and employees' new conditions for control and governance at the workplace
- decision-making and responsibility
- organisation of work
- organisational and social work environment
- organisational resources, such as training and user influence
- organisational structure and organisational culture
- organisation's safety culture
- design and development in organisations.

The formulation of search terms for the structural perspective targeted AI and robotics in relation to:

- structural labor market changes (see previous literature reviews)
- normative aspects and regulations that may impact the work environment and work environment management
- structural discrimination (identification and potential remedies) that may influence individual organisations' work environment and work environment management
- structural risks and safety aspects of the work that may influence the work environment and work environment management.

Based on these areas, several test search templates were designed that were later evaluated and refined. The searches were limited to the ten-year period of 2010–2020. The assessment is that this timespan should capture the research literature that specifically addresses the development of AI and robotisation relevant to working life applications, while remaining manageable in terms of volume.

The expert group received the final searches from the databases *Business Source Complete, Medline and PsychInfo* in December 2020. The searches produced a total of 4,008 articles, 1,919 of which pertaining to the individual perspective; 1,263 to the organisational perspective; and 826 to the structural perspective. The final search templates and search results can be found in appendices 4a-c.

The search results were evaluated based on the inclusion and exclusion criteria after screening the titles and/or abstracts. Articles chosen during the first screening round were then read more thoroughly. In the end, 208 articles were included as relevant for the literature review, 103 of which pertain to the individual perspective; 71 to the organisational perspective; and 34 to the structural perspective. The results presented in the articles were analysed based on the pre-determined research perspectives, with an abductive approach to the identification of themes under each research perspective. The presentation of the research below is therefore divided within the different perspectives in a way that is not entirely consistent with the structure of the search terms.

6. Result compilation – The individual perspective

Many studies are about perceptions and attitudes related to the use of AI systems and robots, and how this affects the work of individuals and groups. These studies are primarily about perceptions and attitudes among people who have no personal experience working with AI (Abdullah & Fakieh, 2020; Calitz et al., 2017; Chen et al., 2019). It can clearly be seen that many people are convinced that AI and robotisation will change the labor market and that work will be automated (Mrowinski et al., 2019). One study indicates that a majority of doctors believe that the implementation of robot-assisted surgery will increase the value of employee roles and job satisfaction, while nursing and technical staff were uncertain about these benefits (McBride et al., 2019). Many articles also describe anxiety and challenges from a user perspective, including issues of privacy, autonomy, and dehumanisation (FoschVillaronga et al., 2019; McClure, 2018).

Among the articles identified as pertaining to the individual perspective about half deal with robots and surgery. In this area there were articles about many different aspects of the work environment. The relatively large number of articles focused on robots and surgery can be understood in different ways. In surgery, people have historically felt positively about new technologies and the work is technology-intensive. There is also a strong tradition here of extensive funding and scientific production. However, it is clear that this is primarily about doctors' use of the technology and not at all about use by other medical professionals.

6.1. Professional knowledge and competence

The results show that for some professional groups AI and robotics provide support, while other professional groups or work tasks are instead replaced by AI and robotics. The likelihood that an occupation is supported, or alternatively replaced, by AI and robotics is partly associated with the level of education required by the tasks (Gardberg et al., 2020), how complex they are, and how much contact with people the work involves.

Research on surgery indicates that inexperienced professionals benefit more from AI and robotics at work with respect to workload, stress, performance, and ergonomics (Chandra et al., 2010; Passerotti et al., 2015). The discrepancy between experienced and inexperienced surgeons not only in terms of workload, stress, performance, and ergonomics, but also in surgical outcomes, becomes smaller when using robot-assisted surgery (Lau et al., 2020; Leite et al., 2016; Nguyen et al., 2020). Studies on robots and surgery thus indicate

that less experienced surgeons learn to operate faster and with better results with robotic surgery than with regular surgery. By using the robot, the surgeons experienced both a reinforcement and less cumulative strain with regard to haptics, vision, and hearing. These physical reinforcements and strain reduction impacted the combined performance and led to adaptations (spatial relocation, reallocation of tasks) which over time resulted in reallocation of roles, including increased professional knowledge, development of new specialisations and changes in status and delimitations (Sergeeva et al., 2020).

6.2. Autonomy and trust in technology

Autonomy and automatisation at work are factors that impact the work environment in relation to the investigated technologies. Research on the balance between autonomy and automatisation appears to be in its infancy, but there are some articles on this topic. The research has shown that automatisaton that takes control, while providing explanatory information, is perceived as more reliable (Verbeke & Verguts, 2019; Verberne et al., 2012). When people know what the recommended decisions from automatisation are based upon, they trust the technology more. Some research even indicates that people's performance, trust, and perceived usefulness increased as a function of the level of transparency about the basis for the decision. Transparency in this context refers to how easy it is for people to understand the basis for the technology's recommended decision. This could be in the form of statistics or visualisations of different types. However, there have been misgivings that in this context, transparency could increase the workload, because the human being in AI, robotisation and automatisation situations must interpret the reasons why a decision is to be made and on what grounds. However, research on this subject has been ambiguous and it is not clear that the workload is affected by the transparency of provided information. Nor does transparency necessarily have to increase the response time, which was another concern (Mercado et al., 2016).

Research shows that increased trust in automatisation or AI systems leads to greater use of the system. Moreover, research shows that use is strongly affected by the nature of the specific task that will be replaced by a robot (Silverstein, 2010). One study showed that people chose a robot more often for a hazardous task in which human life could be in danger. Conversely, people were chosen over robots for more everyday tasks (Sanders et al., 2019).

Some research shows that automatisation can increase efficiency at work and shorten response times. At the same time, automatisation can also create interruptions in the workflow and a need for workarounds, thus reducing the efficiency (Walsh et al., 2011). A *workaround* is a strategy for getting around a perceived problem in the use of the system. The problem could be of different kinds and could involve deselecting a given parameter or tricking the system by choosing another entry.

6.3. Work-related stress

The use of AI and robotics occasionally leads to a reduction in work-related stress, thanks to a reduced workload due to lower physical, psychological, or cognitive demands (Chen & Barnes, 2012). Examples of this have been observed in self-assessment tests of psychological stress, as well as in estimates of physiological stress by measuring pulse, skin conductance, cortisol levels etcetera (Heemskerk et al., 2014; Hubert et al., 2013). Examples of reduced work-related stress have also been demonstrated in work using surveillance cameras (Dadashi et al., 2013), in health and medical care, in the manufacturing industry as well as when using self-driving vehicles (Cottrell & Barton, 2013; Heikoop et al., 2019).

However, studies show that the use of robotics can also cause frustration among some professional groups, which varies depending on the type of operation being automated or carried out with robotic support (Cavuoto et al., 2017). Another important aspect in this context is stress, fears, and concerns linked to the actual introduction of AI and robotics. It is clear that such fears exist (Sinha et al., 2020). There is research intended to attempt adapting the level of automatisation in the system to the human stress level (Lim & Sohn, 2020).

6.4. The ergonomic work environment

Around 10 articles related to robotics and the physical work environment were found in the literature review, primarily in studies from the manufacturing industry (Locks et al., 2018) and from health and medical care (Chandra et al., 2010; Dalager et al., 2020).

The majority of those studies that deal with robotics and the physical work environment within surgery show that the use of robotics has a variable impact on ergonomics, the physical work environment. Some studies indicate positive changes (Dalsgaard et al., 2020), while others show that the changes have led to both deterioration and improvement. The studies are based on both physical measurements and self-assessment forms (Armijo et al., 2019). Either, some work tasks may be replaced entirely by robotics, which means that an ergonomically poor working position in connection with a given task disappears entirely. Alternatively, some tasks can be supported by robotics and in this situation the results show that the tasks become more ergonomically favorable than they would have been if they had been carried out completely manually (Armijo et al., 2019). However, some studies show that the physical work environment may become worse with robotic surgery (Craven et al., 2013).

Several articles are about muscular pain in surgeons when conducting robot-assisted surgery, which can be explained by strenuous positions during the work (Dwyer et al., 2020; Wells et al., 2019). When pain during robotic surgery was compared with regular laparoscopic or open surgery, robotic surgery scored lowest for pain (de'Angelis et al., 2015; Wells et al., 2019).

Familiarity with the system and knowledge of ergonomic adjustments are important for reducing

the risk of musculoskeletal pain during robotic surgery. System improvements may be required to improve ergonomics and to adapt the system to very short and very long surgical procedures. Similar improvements and better training are proposed for reducing musculoskeletal pain during robot-assisted surgery (de'Angelis et al., 2015; Wells et al., 2019).

It should be emphasised that many robot-supported tasks can produce ergonomic problems such as excessive physical load on certain muscle groups, muscle fatigue, and pain in the muscles, bones, and joints (Armijo et al., 2019). To some extent, different muscle groups are activated during robot-assisted surgery compared with traditional surgery (Armijo et al., 2019; Rodrigues Armijo et al., 2020; Rodriguez et al., 2019). For example, robot-assisted surgery required more use of the neck and shoulders, while traditional laparoscopic surgery was associated with increased muscle fatigue in the forearms (Armijo et al., 2019). The results indicated that in most cases, robot-assisted surgery was more beneficial in terms of physically measured muscle load. However, the difference in muscle activation and muscle fatigue between robot-assisted and traditional laparoscopic surgery was less clear among more experienced surgeons (Rodriguez et al., 2019). One study also points to the risk of breaks being shortened when the work is automated (Locks et al., 2018).

6.5. Risks and safety from a work environment perspective

Many of the studies in the literature search focused on the technical potential of AI and robotics in relation to work environment risks and safety. One area considered in the research is the use of AI to create "smart decision systems". These systems contribute to reducing complexity for users by analysing information through AI and recommending decisions or measures. However, these systems are occasionally inadequate and errors can occur. Some research has been conducted on when and why people follow the system's recommendations in erroneous and correct cases, respectively. The results show that inadequate systems reduce trust in automatisation, and reduce usability, acceptance, and overall performance (Brauner et al., 2019).

Studies also address how to help people understand what has gone wrong when automatisation or AI has made the wrong decision (Dehais et al., 2011), and how to design such help (van der Kleij et al., 2018). Further, several studies show how AI can be used to measure and predict risks in the work environment (Bauer et al., 2018), as well as health outcomes connected to work environment problems.

There are several studies on how to support decision-making in complex situations and how to improve decision-making (Tremblay et al., 2017). Other studies demonstrate that trust in the system increases in contexts in which people are working with multiple things simultaneously and when the work is connected to risk (Sato et al., 2019).

However, a very limited number of empirical studies evaluate AI and robotics in relation to risks and safety from a work environment perspective.

6.6. Equal opportunities and gender equality

From a gender equality and equal opportunities perspective, the research is very limited. Equal opportunities involves research connected to the seven grounds of discrimination described in the law. They are:

- gender
- gender identity or expression
- ethnicity
- religion or other belief
- disability
- sexual orientation
- age.

The research demonstrates that age and gender are not necessarily related to the level of ergonomic problems. However, a robot's usefulness in terms of ergonomics might be better adapted to certain body types. This means that people who do not fit the standardised template (for example, very tall or short people) experience worse ergonomic conditions when using the robot (Lee & Lee, 2017).

There are very few studies on AI, robotics and the work environment with an equal opportunities perspective. One study evaluated how robotic wheelchairs could be improved (Carlson & Demiris, 2012). A study on sensory feedback in robotic surgery points to gender differences in the cognitive effect on women and men (Nuamah et al., 2019).

Autonomous, driverless cars can offer better opportunities for mobility for people with disabilities, such as impaired vision. In one study, a prototype was designed in collaboration with people with visual impairment. The result was positive in that the participants expressed increased trust in self-driving car technology, increased belief in its likely usefulness, increased desire to buy one, and reduced fear of failing to manage the technology (Brinkley et al., 2019).

7. Result compilation – The organisational perspective

Research on AI, robotics, and organisational aspects of the work environment is relatively new. The scientific disciplines that have historically studied the work environment from an organisational or leadership perspective, or as part of human-computer interaction, have only recently begun to explore the area. Very little research explicitly addresses the impact of AI on the work environment. The majority of the literature presented here addresses aspects with links to work environment issues, even if the research often does not use the term "work environment".

When sorting the literature, two observations can be made. First, the overwhelming majority of projects describe technical research on new systems, models, or algorithms said to be able to provide better conditions regarding certain aspects of work in organisations, for example for effectiveness, decision-making or safety. Second, almost half of the articles are speculative or discussion essays that do not report a specific study on AI, robotics, or the work environment, but that instead discuss probable implications of the technology based on previous research and experiences.

The four most frequently occurring sectors of working life in the literature are:

- health and medical care
- transport
- manufacturing industries
- the public sector.

There is also some research in the finance, energy, and insurance sectors, but this primarily addresses the development of algorithms that can optimise decision-making in various ways.

Research on AI, robotics and the work environment points primarily to five important organisational issues, which are presented individually below:

- safety
- culture
- decision-making
- leadership
- trust and accountability.

7.1. Safety

Safety in the workplace, especially in relation to physical robots in the manufacturing industry, logistics and health and medical care, is a recurring theme. It is addressed in two ways: On the one hand, the research analyses how work safety is affected, and to some extent worsened, by the use of robots (Bi et al., 2021; Granzer et al., 2010; Gualtieri et al., 2021; Khalid et al., 2018; Parigi Polverini et al., 2017; Vicentini et al., 2020; Wolbring & Yumakulov, 2014) and, on the other, researchers present various proposals for intelligent algorithms that can improve safety (Bascetta & Ferretti, 2019; Bozhinoski et al., 2019; Haddadin et al., 2012; LaBranche, 2011; Woodman et al., 2012; Zhou et al., 2020).

One recurring theme is the connection between privacy and data protection. Even if this is not described as a work environment problem, it is already known that shortcomings in data protection can produce perceived privacy issues, which make this an important aspect of the work environment (Källström, 2000; Astvik et al., 2020). This aspect is also connected to trust and accountability, which will be expounded upon below.

7.2. Organisational culture

Some of the research studies different aspects of organisational culture in terms of their importance for how AI and robotics impact the work environment. One theme in particular addresses employee attitudes toward, and acceptance of, robots and autonomous systems, and how they are designed.

Acceptance of robots can vary significantly in different working life sectors (Savela et al., 2018). Research shows that both organisational norms related to technology and external societal norms influence how meaningful and safe employees perceive working with robots to be, and how strong their acceptance or aversion becomes (Cao et al., 2020; Holford, 2020; Złotowski et al., 2017).

In one study of service robots in the retail sector, Meyer and colleagues conclude that two variables affect how employees perceive robots: the perceived loss of status and the experience of inconsistency in their tasks and professional role (Meyer et al., 2020). Previous research on change processes shows that attitudes toward AI can be analysed, manifested, and affected through different narratives that are shaped and circulated in the organisation. For example, one study shows how the implementation of different AI projects in a Finnish financial services company, seen as a leader in digitalisation, was accompanied not only by stories supporting and praising the digitalisation process, but also by critical stories (Poudel, 2019). The relationship and encounter between different "digitalisation narratives" impacts the daily work environment and workers' well-being.

7.3. Organisational decision-making

A large amount of research from different disciplines, such as interaction design, informatics, organisation and management studies, and computer science focus on decision-making from various aspects. Artificial intelligence is seen here either as the replacement of or support for human decision-makers in different organisational contexts. Examples include diagnoses in health and medical care, hiring decisions, and decisions regarding energy use. The survey shows that most of the published research on AI and decision-making is based on computer science and aims to find new models capable of in various ways streamlining decision-making relating to work environment issues, such as decision-making on safety and productivity.

Some research focuses on the interaction between people and technology/ algorithms in decision-making processes and the consequences for the organisation and employees. These studies are driven by questions such as:

- What happens to human involvement in decision-making when intelligent algorithms are introduced?
- How can the interaction between people and intelligent algorithms be designed?
- What consequences do different kinds of user interfaces have on employees' experience of the decision-making?

SSuch questions are relevant in order to understand how AI affects the work environment from an organisational perspective, even if the work environment is not usually explicitly the focus in these publications.

The research findings demonstrate several interesting aspects. The interaction between people and AI systems leads to better decisions and a more positive experience of the decision process if it is structured as a collaboration supporting shared decisions between humans and technology, compared to when it is structured as a supervisory relationship (Azhar & Sklar, 2017). Several researchers propose that AI should be viewed more as an opportunity to strengthen human intelligence than to replace it. For example, both Jarrahi and Cukurova and colleagues discuss intelligence augmentation (Jarrahi, 2018; Cukurova et al., 2019). Some types of decisions are more suited to being made by AI systems than others. Research shows that decisions associated with assessments of the abilities of other people are particularly difficult to leave entirely up to AI systems (Krupiy, 2020). This may have important implications in human resource management (HRM) and the use of AI technology there.

Very little research investigates the effects of automatic decision-making on experiences of autonomy, discrimination, or other organisational aspects.

7.4. Leadership

Some research, discusses the implications of AI applications for leadership within organisations. A few articles about leadership are based on empirical studies and point to the importance of leadership style and influence. Xu and colleagues studied the consequences of service robots for leadership and HRM in the hospitality industry (Xu et al., 2020). Their research shows that service robots can be expected to improve efficiency, but that it is important for leaders to encourage openness and to themselves embrace the changes in order to look after the work environment. In interview studies about AI and company management, both Noponen and Kolbjørnsrud note that with the automatisation of routine tasks, leadership will come to be even more about "soft skills", collaborative abilities and interpersonal relationships, than it is today (Noponen, 2019; Kolbjørnsrud et al., 2017).

A great deal of leadership research is in the form of essays developing rhetorical arguments based on previous research on leadership, instead of being based on empirical studies on how the leadership role is changed by automatic decision-making or other kinds of AI applications.

7.5. Trust and accountability

One theme that few articles address is how AI impacts trust and transparency in organisations' decision-making. Systems that use AI are often perceived as non-transparent and connected to ethical questions, which can generate a lack of trust in the technology and the decision-making (Bejger & Elster, 2020). Other researchers show that knowledge about autonomous systems and their functions, for example about how safety works in autonomous vehicles (Khastgir et al., 2018), can help improve trust. Accountability is also discussed in relation to AI use in particular work contexts as well as in HRM (Tambe et al., 2019) and military work (Sehrawat, 2017). Researchers argue that to a significant extent, AI systems must be able to be understood by users in order for the systems to be able to explain autonomously made decisions.

8. Result compilation – The structural perspective

Research on how AI and robotics affect structural aspects of the work environment, such as laws, regulations, societal norms, and structural changes in the labor market, is relatively limited. The literature search shows around 30 relevant articles which have been compiled below. Many of them are speculative or discuss various possible implications of AI for legislation, societal norms, and the labor market. Few of them are empirical. The analysis suggests five themes:

- discrimination
- ethics
- labor market changes
- media influence
- transparency and privacy.

8.1. Discrimination

Like many popular science texts, research has also noticed that decision-making using AI technology can be perceived as, and be, unfair, as a consequence and a manifestation of human preconceived opinions in the design and training of the algorithms (Howard & Borenstein, 2018). This can also create serious work environment problems. Unfortunately, research on this problem is poorly developed and is more speculative than empirically based. However, there are a few important contributions to the discussion on AI, discrimination, and its impact on the work environment. Some researchers discuss organisational justice as a basis for assessing AI and autonomous decisions (Robert et al., 2020). Other research points out that organisations that use externally developed AI systems perceive fairness and discrimination as being beyond their control (Khatry, 2020).

8.2. Ethics

Many ethical questions around applications of AI that are discussed in the research are relevant to the work environment. These involve the relationship between AI systems and people at work, the impact on employee well-being and rights, as well as the use of AI in work with vulnerable groups. Around 15 articles have been found that address these issues and connect them in some way to employee well-being and perceptions of fairness. All of these articles

Are in the form of discussions based primarily on a philosophical and legal understanding of ethics. None of them are based on empirical studies or investigate ethics in practice.

Some articles discuss general ethical themes such as the relationship between people and machines at work (de Graaf, 2016; Orr & Davis, 2020) or human rights and privacy in the use of AI at work (Estlund, 2018; Kriebitz & Lütge, 2020). Other articles address ethical questions about the use of AI in specific work contexts and situations. The sector that has received the most attention in terms of ethical questions is AI use in health and social care (Johansson, 2013; Vanderelst & Willems, 2019), especially with children (Tolksdorf et al., 2020) and the elderly (Gallagher & Breines, 2020; Körtner, 2016; Misselhorn et al., 2013; Wachsmuth, 2018). Children and the elderly are both considered particularly vulnerable groups, where research is called for on context and situation specific considerations in the practical use of AI. Ethical questions in health and social care are defined in terms of empathy, dignity, dependence, and autonomy.

8.3. Labor market changes

Some research focuses on the effects of AI and robotisation on the labor market overall, as well as on matters related to labor market changes, disappearing jobs and unemployment. This kind of research has some relevance for understanding consequences in the work environment, as ideas and future scenarios for different professions influence how employees experience their work situation. Even if this research does not ask questions that directly address the work environment, it still has some relevance. Concerns about future unemployment and labor market changes may have implications for how meaningful people experience their work to be, as well as how work is organised and developed in order to meet future challenges.

Research in this area can be divided into two themes: On the one hand, there is research that calculates which professions and tasks may be replaced or supported by machines (Chessell, 2018; ConnollyBarker, 2018; Rafi Khan, 2018) and, on the other, there is research on which new professions, tasks, and skills may be created (Agrawal et al., 2019; Colombo et al., 2019; Nica et al., 2018).

8.4. Media

One theme that very few articles address is how media portrayals of AI and robots influence how employees experience their workplace, their future, and trust in machines. In one study, Horstmann and Krämer investigate the influence of media images of social robots and how people experience them at work (Horstmann & Krämer, 2019). Their research shows that ideas about robots spread by media lead to high expectations regarding the abilities of social robots at work and in personal life.

In another study, Mara and Appel conducted a psychological experiment to test whether narratives in fiction about robots affect people's relationship with human-like robots (Mara & Appel, 2015). Their research shows that the fictional narrative significantly reduced the degree of fear people experienced in their relationship with the humanoid robot "Telenoid" that was used in their experiment.

8.5. Legislation on privacy and transparency

As described in previous sections, some research addresses privacy and transparency as important aspects of individual and organisational work environment management. A few researchers, especially in law, analyse the need for normative changes to enhance privacy and transparency, particularly related to data protection, in conjunction with the use of AI in organisations (Mougdir, 2020; Pagallo, 2013).

9. Summary of the literature searches

Much of working life-oriented research on AI and robots focuses on the impact on different professional groups, their future, and their skills. At the structural level, the research has, in several ways and in many studies, calculated which professions will be affected or disappear entirely. This question has also been relevant in the public debate for several years. Research groups have conducted various kinds of forecasts regarding how AI and robotisation may impact the labor market and unemployment. The calculations are not unanimous, but bring up several important questions about the future of industries and professions. There seems to be agreement that AI and robots will largely replace routine tasks, but that this does not necessarily mean the occupations will disappear entirely; rather, they will change, and new tasks will be added. In particular, it is believed that managers and decision-makers in various organisations will be impacted to a greater extent, and these constitute a professional group that is important for organisational development and the work environment.

Researchers have studied how AI affects the work of different professional groups in practice, especially in relation to their professional skills. The research shows that AI may contribute to some professional groups learning to carry out their tasks and developing their skills faster and more efficiently, while the skills of other groups may instead tend to be eroded. Some professions will receive support from the technology to some extent, while others will be replaced. Automatisation and the use of AI systems may improve the efficiency for some work tasks, and reduce it in other cases. Sometimes new steps will be added to understand what automatisation is doing, to check how it is working, or to find functional workarounds when the technology fails.

The effect of AI on employees' skills becomes a work environment issue from the individual perspective, because it affects the perceptions of meaningfulness at work and of the future prospects of the profession. The research indicates that the work environment may also be affected by media ideas about future development, for example, that media portrayals of AI and robotisation may generate "robot anxiety". Other organisational work environment issues deal with which professional groups are at risk of being replaced, how the relationship between different professional groups will develop, as well as how organisational culture affects and is affected by the changes. The researchers assert that in most cases, the relationship between humans and intelligent machines is not about being replaced, but is rather about the technology being comprehensible and organised as a collaboration, a partnership, where intelligence, assessments, decisions, and actions are allocated between humans and machines. Even if the results of this research are not uniform, it points to the importance of skills development and professional experience for

automatisation and AI to serve as well-functioning support and to be able to contribute to improvements instead of becoming a threat to the professional role.

A considerable amount of research covers automatisation and decision-making. In this area, there is a suggestion that systems designed to reinforce human intelligence generate better results. The research indicates that the transparency of the technology is important for the relationships and interactions between people and technology in decision-making situations. People need to be able to understand what the technology does and how automatisation works. Their trust in the technology is an important component, which is important for the perception of privacy and how it can be ensured. The research clearly shows a very negative effect on trust in the technology when it does not work as intended, but trust increases when the technology is designed with transparency and people are permitted to have an understanding of its function and behavior.

Some research points to the fact that acceptance of and attitudes toward the technology are central for how AI and robotics affect the work environment. Research shows that matters related to organisational culture and leadership are important to consider for a successful introduction of the technology. Acceptance of the new technology may vary significantly in different industries and professions, depending on how people perceive any loss of status, as well as on how society views professional roles and the future of the jobs. Leadership can influence acceptance and the research indicates the importance of openness, competence and how well change processes are able to include human aspects of the jobs and work environment.

Research on safety points out that automatisation can sometimes reduce safety. When AI systems or robots recommend decisions for the purpose of supporting the human, these can sometimes be erroneous. This kind of inadequate AI system reduces trust in automatisation, usability, acceptance, and overall performance, and may also entail risks for the whole operation. It is important deliberately to work on transparency so that people have the possibility of understanding what recommended decisions are based upon and how they can be interpreted and used.

Applications of AI and robotics at work bring up many ethical questions that are important to handle to avoid them leading to problems in the work environment. This involves, among other things, the consequences of discrimination against individuals or groups arising due to bias in the fundamental data and in the models for machine learning. It also involves the impact on particularly vulnerable groups, such as children and the elderly, where the use of AI raises special ethical questions that researchers single out as important to study. Ethical aspects may manifest in different ways in different contexts. For example, the research discusses matters of discrimination, privacy, and responsibility. The relations between technological development, activities and responsibilities of organisations, and society's laws and norms are also studied here.

10. Literature search appendices

List of appendices.

Part 3 – Other sources of knowledge

Part 3 contains a survey and analysis of important knowledge that is not captured by traditional, structured literature searches of databases of scientific publications in accordance with the search criteria that were used.

First, a review will be carried out of previous research, knowledge and experiences that are relevant to how the new technologies are applied in working life.

Additional material describing the current state of knowledge in Sweden has been gathered via searches of organisations' information pages and through targeted questions to representatives of Swedish organisations within research, government agencies and working life organisations.

11. Other sources of knowledge – Introduction

The structured literature review presented above offers a picture of research on AI, robotisation, and the work environment, published in scientific reports in the past decade. To complete the picture of the current state of knowledge provided by these searches, additional surveys and analyses have been carried out. The aim is to:

- Describe earlier research that is relevant to the questions at hand. This mainly involves research on the impact of digitalisation and automatisation on the work environment where the results are also relevant for newer applications of AI and robotisation.
- Survey ongoing important research initiatives in Sweden with connections to AI, robotisation, and the work environment.
- Survey and analyse relevant research and knowledge that has not been published as scientific reports as well as reports that are not strictly scientific in nature, but which still convey important information and experiences. This survey is limited to Sweden and to the past five years. It involves research on the work environment, as well as research that does not explicitly describe the impact of the use of AI and robotisation on the work environment, but which may indirectly contribute to such knowledge.
- Describe other relevant documents and initiatives that do not constitute research, such as projects carried out by government agencies, interest groups, or employer or employee organisations.

This survey was carried out after consultation with the Swedish Agency for Work Environment Expertise and its reference group of representatives of social partners. It aims to summarise knowledge that is useful for all players with responsibility for the work environment of the future. The focus is on practically applicable knowledge and experiences.

12. Older relevant research

Changes in working life related to new technology, digitalisation, and automatisation are not new. Computers have gone from being in the background and handled by particular staff members to being part of everyone's daily life. Today, digital systems are used in most jobs and in more and more professions all tasks are carried out with the help of technical support. The characteristics of the digital systems, both hardware and software, are thus becoming crucial for how work can be carried out – and consequently, for the work environment. All sectors of working life are impacted. Digitalisation has had many positive effects over the years, but there are also obvious problems.

Automatisation also has a long history, from early industrialisation up to today. Automatic systems, either autonomous or as support for human operators, are common today in most sectors of working life. Advanced new technology, through the use of AI technology and robotisation, among other things, is now creating new opportunities to take automatisation much further.

Researchers have been studying the impact of digitalisation and automatisation on the work environment for a long time. There is solid knowledge about the causes of problems; methods for surveying and analysing them; models for developing effective, safe systems and jobs; as well as how to consider work environment matters in conjunction with the development and implementation of new technology. In most respects, this knowledge and these experiences are also relevant and applicable when studying the effects of newer technology, such as AI and modern robotisation. When it comes to the impact on the work environment, that is, how employees are affected and how they perceive their surroundings, it is not usually important or even interesting for them to know how the technical systems were developed. What is important are the characteristics of the systems and how they impact the organisation, work processes, groups, and individuals. Much of the earlier research is both relevant and applicable here. A brief description of important knowledge and lessons from earlier research is presented below.

12.1. Digitalisation and the work environment

The digital work environment has previously been defined as:

> *"The work environment, with its physical, organisational, social, and cognitive problems and opportunities, resulting from the digitalisation of the work's support system and tools."*

(Sandblad et al., 2018). A report from the Swedish Work Environment Authority, *Digital Work Environment, A Survey*, presents a literature review of digital work environment problems in working life (Gulliksen et al., 2015).

A literature review from the Swedish Agency for Work Environment Expertise, *Work Environment of the Future – Trends, Digitalisation and Employment Forms*, describes the current state of knowledge regarding work environment trends, digitalisation, the work environment, employment forms, health, job satisfaction, occupational injuries, and mortality (Eklund et al., 2020).

Digital work environment problems in practice
There are several surveys within different sectors of working life of how individuals perceive and evaluate their own digital work environment. Most were carried out by labor unions. A few examples of such studies and what they show are:

IT-strul kostar välfärden miljarder. Rapport om välfärdens digitala arbetsmiljö [IT Difficulties Cost Welfare Billions: Report on Welfare's Digital Work Environment] (Vision, 2019).

Among other things, the report says:

> *"Seven out of ten of Vision's members work at least 80 percent of the day with the help of digital tools to administer, lead and develop welfare…. In this report, we investigate how Vision's members view their digital work environment. We can conclude that in general, most are satisfied with the user-friendliness of IT systems. That is encouraging! At the same time, there are red flags. For example, loss of time due to IT difficulties has increased by eight minutes per day compared with 2014. Employees also feel that their opportunities for influence when developing or procuring IT systems have declined. We have placed a price tag on the loss of time caused by IT difficulties. Last year the total cost, calculated for all employees in municipalities and regions, amounted to a diszying SEK 29.7 billion! This is money that could be used for very good work instead."* (p. 2)

Unionen's IT Report 2017 (Unionen, 2017).
The report shows that:

> *"Last year, 133.5 million working hours in the private business community were lost to IT problems. The working time cost of these hours amounts to SEK 44.1 billion, and that is not including the costs of IT difficulties among other groups."* (p. 3)

The report also states that only two out of ten white-collar workers receive the necessary training to be able to use IT systems effectively. Only two out of ten white-collar workers agree that IT systems have been introduced on the basis of clear and well-established ideas. Fewer than two out of ten white-collar

workers have the opportunity to influence the design of new work procedures when new IT systems are introduced.

Vård-it-rapporten [Healthcare IT Report] (Swedish Association of Health Professionals, 2010).
The Healthcare IT Report was produced by UsersAward, an initiative by LO and TCO, to survey how healthcare professionals perceive digital systems in healthcare. The survey was carried out on two different occasions: in 2004 (called Vård ITkartan [Healthcare-IT-Map] at that time) and in 2010. A comparison between the two studies shows that a great deal had been improved and there was a clearer understanding of how IT systems could support healthcare work. But clear problems still remained. Among other things, the report says:

> *"The most common direct causes of wasted time are slowness or operational problems in the systems and inadequate integration between different IT systems within healthcare. The increased complexity and over-documentation of medical record systems also generate unnecessarily wasted time. Low usability of medication modules, for example through non-intuitive and unnecessarily complicated user interface design, are pointed out not only as time thieves, but also as a major safety risk for patients."* (p. 11)

Another report from the Swedish Association of Health Professionals, Störande eller stödjande? Slutrapport från projektet *eHälsosystemens användbarhet* [Disruptive or Supportive? Final report from the *Usability of e-Health Systems* project], discusses the shortcomings of the digital work environment within health care (Swedish Association of Health Professionals, 2013)].

A few key areas of knowledge about the digital work environment
Below follows a presentation of some of the knowledge resulting from earlier research that is also applicable for understanding, describing, analysing, and preventing work environment problems when using AI and robotisation.

Cognitive work environment
Cognitive work environment problems arise when the properties of a digital system are not adapted to people's perceptive and cognitive abilities or to the demands of the work. Knowledge of people's cognitive abilities and of cognitive work environment problems must be considered when designing and introducing digital systems (Sandblad et al. 2018).

Stress and health
Stress as a concept has no uniform definition. In science, the term is usually linked to physical reactions to taxing situations, an excessively high workload, or a perceived imbalance between demands and the abilities and support available for meeting them. Often, there is no differentiating between causal factors and the reactions to which they lead; rather, both are called stress. Recovery and rest are absolutely essential for avoidance of harmful stress. It is

when elevated stress lingers for a longer period of time, with no opportunity for rest and recovery, that negative effects can occur. In addition to trying to reduce work environment factors that may lead to potentially harmful stress, one must therefore also identify factors in working life that can help or hinder rest and recovery. Today's high-tech working life likely leads to new demands that contribute to the increase of e.g. sleep problems and mental illness. Sleep disturbances may impair memory and the ability to learn, and make it harder to maintain good concentration, attention, and the ability to react. A severe sleep deficit can have a negative impact on decision-making.[9]

Demand–Control–Support

According to the demand-control-support model, launched by Karasek and Theorell, the relationship between perceived demands and perceived personal control at work (or rather personal governance, that is, how well one has mastered the work, situations, tools, opportunities to decide how to do the work, etcetera) is crucial for whether or not work leads to stress (Karasek & Theorell, 1990). A high level of perceived demands combined with a low level of personal control generates a state of negative tension that can ultimately lead to mental and physical illness. A combination of high demands and high personal control, however, leads to a state of challenges that feel manageable. The greater the control perceived by the individual, the higher the demands they can manage without negative effects. Demands are defined as psychological stress factors at work, for example quality and safety demands, time pressure, or large quantities of work. Demands may come from the individual, or from colleagues, management, the surroundings, customers, patients, etcetera. Control is defined partly as the degree of personal control and self-determination, and partly as stimulation and development, for example through variation in work tasks. However, the research shows that if demands are too high this leads to negative effects such as exhaustion, even if personal control is high. The model was later supplemented with a third factor: perceived social support. The experience of social support can impact the individual's reactions and how they manage a stressful situation. One might say that social support functions as a buffer against stress. With all digitalisation, for example with the introduction of new digital systems or automatisation, it is common for perceived demands to increase. In this case, it is important to ensure that perceived personal control and perceived social support are strengthened or at least not reduced.

There are also other models for describing and analysing what affects people at work, as well as how they are affected by different aspects of the work, but the demand-control-support model has been shown to be a good explanatory model for observed problems in the work environment.

Usability and accessibility

The concept of usability is defined in an ISO standard, ISO 924111, and is measurable. The definition says:

9 https://www.stressforskning.su.se/omoss/allm%C3%A4ntomstresss%C3%B6mn

"The extent to which a product can be used by specific users to achieve specific goals effectively, suitably and satisfactorily in a specific context of use." (SIS 2018).

Another important definition is of accessibility, ISO/IEC Guide 71:2014

"The extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use."

Both of these definitions, which describe how well a digital system supports a certain person for a certain purpose in a certain work context, as well as how well it works for people in different circumstances and with possible functional variations, naturally also apply to cases involving AI systems or robots. Usability and accessibility are necessary conditions for a good digital work environment. Both of these concepts are, however, related to a specific system or a certain product, while the work environment is always related to the experienced entirety of the work context.

12.2. Automatisation and the work environment

Robotisation can be seen as an advanced form of automatisation. The definition of robotisation says that a robot "is a programmed machine which, autonomously or controlled by an operator, can carry out a complex series of automated tasks." The definition also says that a robot can have a physical shape or consist of software, an agent, which more or less independently gathers information, interprets it, handles cases, and makes and carries out decisions. A modern robot can be self-learning with the help of AI technology, but it does not have to be. Robots can be in cars, in industry, can carry out automatic case management or make decisions in different kinds of administrative contexts. There is a large amount of older research about automatisation and the work environment which, properly interpreted and applied, is also applicable to newer forms of robotisation.

A few key knowledge areas about automatisation, robotisation and the work environment

Automatisation principles and levels
Automatisation may look very different depending on what is being automated, to what extent, in what way and in what context. One aspect of this is whether one views automation as something independent or as part of a socio-technical system that involves an interaction with human players. Another aspect is whether the starting point is that a human player must have continuous situation awareness, see below, and the ability to act proactively (control by awareness) or whether the automatisation is based on the approach that the technology acts autonomously until something causes the human to

have to intervene, such as an alarm being set off (control by exception). The different principles lead to entirely different demands on systems and interactions with the human (Kecklund & Sandblad, 2021).

One way to categorise different degrees or levels of automation was formulated already in the 1970s by Sheridan and Verplank (Sheridan & Verplank, 1978), and was later updated (Parasuraman, 2000). Their definition comprised ten levels, from the lowest, "The human decides what will be done and gives the decision to the technology to carry out", to the highest, "The technology carries out the entire action that it has decided and informs the human only if it considers it necessary to inform the human." More recently, other scales of degree of automatisation have been designed, for example when it comes to more or less autonomous cars *(Society of Automotive Engineers, SAE*[10]*)*. Here, the levels range from the lowest, "The driver has complete control over all aspects of driving; warning and intervention systems can support the driver", to the highest, "An automated driving system has control over driving in all traffic situations and environments; the vehicle can be driverless". Each level of automatisation has its own particular questions regarding interaction with human players, safety and risks.

Situation awareness

Situation awareness is an important concept when it comes to understanding a person's chances of understanding, mastering, and controlling a complex sequence of events, for example controlling a dynamic process in industry, healthcare, administration, vehicles, or transport. A basic definition was drawn up by Mica Endsley (Endsley, 1995). Situation awareness is defined as consisting of three aspects:

- perception
- comprehension
- projection.

Perception involves gathering information about the situation; comprehension involves interpreting and understanding what this information means in the context; and projection involves being able to predict what will happen next, both spontaneously and as an effect of the actions taken. Good situation awareness is a precondition for a human, for example in an interaction with an automatic system or robot, to be able to understand what is happening and act effectively and safely, and to feel in control of what is happening, to be "in the loop".

Automation surprises

Automation surprises refers to an automatic system or robot doing something that a human player does not understand or did not expect in the given situation (Sarter, 1997). This is often due to the automatisation not being part

10 www.sae.org/autodrive

of the human's mental model of the process to be controlled. As a result, they cannot understand or predict what will happen and become uncertain, which can result in stress as well as safety problems.

Irony of automation

Another effect that can occur when human players collaborate with automatic systems is "the irony of automation" (Bainbridge, 1983). There are several interpretations of the concept. One interpretation is that the more stable and reliable a technical system and its automatic functions are, the less attention the human needs to pay to the process. This makes it increasingly difficult to detect when deviations occur or to adequately intervene. The operator trusts that the automatisation will fix everything and attention wanes, and ultimately so does the ability to take the correct action in difficult situations. Thus in this regard, the irony is: "the better the automation, the worse the operator".

Another interpretation is that as long as the automatic systems handle the situation and everything functions undisturbed, the automatisation provides the operator with good support. But if something no longer works and the human must act manually in order to regain control over the process, the human no longer has any help. In other words, when everything is working and the human does not have much to do, help is present. But if problems arise and the human suddenly has much to do and really needs help, there is none to be found.

Autonomy and authority

An automatic system that is constructed to be able to act entirely independently, to be able to make and carry out its own decisions, can be called autonomous. The opposite is a non-autonomous, subordinate machine. The autonomous machine can change the operator's plans and thus cause automation surprises, and contribute to the irony of automation. A non-autonomous machine can support the human, the operator, by effectively carrying out their decisions or intentions. It supports the operator's action in every situation, only performs what the operator wants to have done, relieves the operator from carrying out the task, and can never create automation surprises. It complements the operator's work by optimising the tasks to be carried out. An autonomous machine, on the other hand, can always be active, can relieve the human of burdensome activities, and in some situations, can act faster and more reliably. There is no accepted truth about which kind of automatisation is the best. It depends entirely on the situation and the design (Endsley, 2017).

When autonomous machines are part of a complex socio-technical system, e.g. controlling an industrial process, a nuclear power plant, an airplane, or a car, a question arises about who makes the decisions. Do the human players, the operators, have the last word, or does the machine? Who has the right to decide or take over from the other if something goes awry? This is a question of authority – who is superior to whom? There are both positive and negative experiences of both kinds of authority principle.

12.3. Human, technology, organisation, and the socio-technical perspective

The human, technology, organisation (HTO) perspective involves an overview, a system view, in terms of analysis and construction of socio-technical systems. A socio-technical system consists of people in different roles interacting with the technical system. A central part of the HTO perspective is to systematically use information about how people function in interaction with one another and with the technology in order to design good interaction between the human, technology, and organisation (Kecklund & Sandblad, 2021). There are methods for using knowledge about humans and technology in the design of operations, and for having an overall and system perspective on safety and effectiveness at work. The concept of HTO was originally used within nuclear power safety. It was established in the late 1980s to clarify that this involves an interaction between different system components and that organisational components must also be given consideration. This is crucial when designing complex socio-technical systems for safety, sustainability, and a good work environment. Different aspects of the HTO perspective and its methods may be relevant for different problems. Examples of methods based on this are risk analyses, incident investigations, and questions concerning the safety culture in organisations.

12.4. Resilience

Resilience is a concept that was coined by researchers and practitioners who wanted to emphasise the importance of not only studying safety relative to human error or reliability. A resilient system, here primarily with reference to socio-technical systems, is highly resistant to disruptions and has the ability to recover when disrupted, within reason. This is not only about individual technical systems, but the observed organisation as a whole (Hollnagel, 2006). Resilience involves the approach, competence, processes and continuous change and development initiatives aimed at creating the greatest possible resistance to undesired incidents while making use of all opportunities to learn from everything that happens, the good and the bad, in order to continuously improve. Related to resilience, the concepts of Safety I and Safety II have also been discussed. The difference between them is that Safety I focuses on what has gone wrong and what caused it, while Safety II focuses on what has gone right and what can be learned from that. In other words, to "learn from health" and build safe systems based on that knowledge (Hollnagel et al., 2015).

The concept of resilience is used in this context to describe safety-related problems in socio-technical systems. This concept is also used in other sciences; for example, psychological resilience refers to an individual's ability to handle personal crises or unexpected events.

13. Some current research initiatives in Sweden

There are several extensive AI-related research initiatives in Sweden. Essentially all Swedish universities and colleges conduct research on AI and robotisation. Several of the agencies and foundations that fund research have initiated comprehensive and cohesive programs, often consisting of both research and graduate schools. Described in brief below is a selection of those where there is some connection to work environment issues, even if that connection is not always clear. This list is not complete and new initiatives, programs and projects are regularly being added. The organisations named below are among those with more extensive operations. It is not relevant to go into the details of individual projects here, as changes occur quickly.

13.1. The Wallenberg AI, Autonomous Systems and Software Program

The Wallenberg AI, Autonomous Systems and Software Program (WASP) research initiative is a national initiative for strategically motivated basic research, education, and academic services. The presentation of the initiative on their website reads:

> *"The main focus of the research within WASP is artificial intelligence and autonomous systems acting in collaboration with humans, adapting to and learning from their environment through sensors, information and knowledge, forming intelligent systems-of-systems. Software is the main enabler in these systems and is an integrated research theme of the program. The research in WASP can be illustrated as a matrix with two dimensions, a strategic dimension and a thematic dimension. The strategic dimension emphasises areas of impact on individuals, society, and industry, whereas the thematic areas represent the underlying scientific and technological challenges that are common to all types of autonomous systems."*

Research within WASP is conducted at seven Swedish universities and colleges: Chalmers University of Technology, KTH Royal Institute of Technology, Linköping University, Lund University, Umeå University, Örebro University and Uppsala University.[11]

11 https://wasp-sweden.org/research/

13.2. The Wallenberg AI, Autonomous Systems and Software Program – Humanities and Society

The purpose of *The Wallenberg AI, Autonomous Systems and Software Program – Humanities and Society* (WASPHS) research initiative is to increase knowledge about the possibilities and challenges entailed by the implementation of artificial intelligence and autonomous systems, as well as the changes to which the technology shift leads. The program, which will be running during 2019–2028, is interdisciplinary and combines humanities and social science with technology research.

The research in WASPHS is about the challenges and effects of upcoming technological changes and will develop theory and practice for human and societal aspects of AI and autonomous systems. The research is to be based on the humanities and social science. In particular, the focus is on potential ethical, economical, labor market-related, social, and legal aspects.

The WASPHS research program includes around 30 research projects, a national graduate school, the establishment of new research groups as well as support for guest professors. Umeå University is the host university of the program. Research within WASPHS takes place at eleven Swedish universities and research institutions: Chalmers University of Technology, University of Gothenburg, Stockholm School of Economics, Institute for Futures Studies, Karlstad University, KTH Royal Institute of Technology, Linköping University, Lund University, Stockholm University, Umeå University and Uppsala University.[12]

13.3. Research Institutes of Sweden

The so-called AI Agenda[13] is an initiative by Research Institutes of Sweden (RISE[14]) through which in 2019 various players participated in workshops and formulated proposals for activities, based on what they believe would make a difference for Sweden's effort to become the leading country in using the opportunities of digitalisation for a sustainable future. The introduction to the agenda states:

> *"Sweden will be best in the world at making use of the opportunities of digitalisation. AI and automatisation make the problem-solvers of our time better placed to handle important societal challenges. To create maximum movement in a common direction, around 50 players from the business community, academia and the public sector have developed an AI agenda for Sweden. The AI Agenda contains recommendations regarding investment needs and policy development in numerous areas, formulated as 25 specific proposals."*

12 https://wasp-hs.org/sv/forskning-wasp-hs/
13 https://www.ri.se/sv/ai-agendan
14 https://www.ri.se/sv

The Center for Applied AI at RISE[15] intends to *"engage in advanced research in AI, connect expertise with applications within RISE and explore a broad spectrum of innovative applications with companies and the public sector"*.

A large number of projects about AI and robotisation are under way within RISE. None of the described priority areas contain anything explicitly linked to the work environment, but the results can, and should, potentially be interesting for future work environments as well.

15 https://www.ri.se/sv/ai-centrum

14. Other initiatives, programs, reports etcetera

Several different government agencies, with different kinds of responsibility for work environment issues, have produced literature reviews, reports and guidelines that address matters related to AI, robotisation and the work environment.

14.1. Government agencies and other players

Several different government agencies, with different kinds of responsibility for work environment issues, have produced literature reviews, reports and guidelines that address matters related to AI, robotisation and the work environment.

The Swedish Agency for Work Environment Expertise, in a literature review from 2020, has summarised knowledge from the research literature about work environment trends, particularly with regard to digitalisation and new employment forms, with a focus on consequences for the work environment.[16]

The Agency for Digital Government (DIGG) has been tasked with coordinating and supporting digitalisation with the aim of making public administration more efficient and fit for purpose. The agency shall also foster the ability of public administration to use AI and has formulated a policy document (2019) that analyses the opportunities and capacity for public administration to use AI well. It does not contain any aspects that are clearly related to the work environment, but covers several guidelines that are relevant to the work environment.[17]

The Swedish Gender Equality Agency has been tasked with follow-up, analysis, coordination, knowledge, and support towards achieving the gender equality policy goals. The agency has published the results of a dialogue on AI and gender equality (2021).[18]

16 https://mynak.se/publikationer/framtidens-arbetsmiljo-trender-digitalisering-och-anstallningsformer/
17 https://www.digg.se/4a3a73/globalassets/dokument/publicerat/publikationer/framja-den-offentliga-forvaltningens-for- maga-att-anvanda-ai.pdf
18 https://www.jamstalldhetsmyndigheten.se/files/2021/02/AI-och-Jamstalldhet.pdf

The Swedish Work Environment Authority[19] has published the following knowledge compilations, among others:

- *The brain-friendly workplace – cognition, cognitive impairments, and work environment*[20]
- *Digital work environment*[21]
- *New ways to organise work (RAP 2018:2).*[22]

The Swedish Agency for Growth Policy Analysis produced a report on AI policies in support of competitiveness. (Ref no.: 2020/257).[23]

The report aims to contribute knowledge

> *"capable of increasing the ability of decision-makers to understand and relate to the area of AI. This is particularly important because AI affects all business sectors and is believed to have significant effects on Sweden's competitiveness. "The report "analyses which rules Swedish companies must take into account in the EU's new proposal for an AI regulation". It is asserted that AI raises "new kinds of questions about ethics, explainability, human rights, and democracy. Dangers in the analogue world can easily be transferred to and accentuated in the digital world. Critical questions include how companies design comprehensible AI systems in which it is possible to understand what the systems are doing, and whether users can hold anyone accountable for tasks performed by AI."*

The report describes the comprehensive effects that AI may have on businesses and jobs, but does not explicitly address any matters related to the work environment.

The Swedish Agency for Economic and Regional Growth has initiated "an AI network for government agencies". Its purpose is described as follows: "Several government agencies have tested and developed different AI solutions, such as virtual assistants, automated decision support and machine learning. Others are still at the starting blocks. The Swedish Agency for Economic and Regional Growth is inviting government agencies to an AI network to promote collaboration."[24]

In 2020, the Parliamentary Committee on Industry and Trade held a dialogue entitled *Artificial intelligence – Opportunities and challenges for Sweden and Swedish companies.*[25]

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19 https://www.av.se
20 https://www.av.se/globalassets/filer/publikationer/kunskapssammanstallningar/den-hjarnvanliga-arbetsplatsen-kunskapssammanstallningar-rap-2014-2.pdf?hl=intelligens
21 https://www.av.se/arbetsmiljoarbete-och-inspektioner/kunskapssammanstallningar/digital-arbetsmiljo-kunskapssammanstallning/
22 https://www.av.se/arbetsmiljoarbete-och-inspektioner/kunskapssammanstallningar/nya-satt-att-organisera-arbetet/?hl=nya-satt-att-organisera-arbetet
23 https://www.tillvaxtanalys.se/publikationer/pm/pm/2021-07-06-ai-politik-for-konkurrenskraft.htm
24 https://tillvaxtverket.se/om-tillvaxtverket/samverkan/ai-natverket.htm
25 https://www.riksdagen.se/sv/dokument-lagar/dokument/rapport-fran-riksdagen/artificiell-intelligens---mojligheter-och_H80WRFR4

The Equality Ombudsman (DO) discusses in a statement (2020) the development and use of intelligent systems (AI) for automated decision-making. They warn that discriminatory algorithms can be unintentionally built in or automatically created, which can lead to a very large number of individuals being discriminated against, without this being realised either by them or by the people responsible for the system.[26]

The Swedish Association of Local Authorities and Regions (SALAR) describes their initiatives regarding AI and automatisation within their interest areas as follows:

> *"Automation and artificial intelligence (AI) create opportunities for smarter welfare. SALAR wants to contribute to ensuring these opportunities are beneficial and create value in welfare. The majority of automation up to this point has been based on technology or programs designed to carry out a task in a predetermined way. AI also creates possibilities for automation of unpredictable tasks. This generates new opportunities for municipalities and regions while at the same time changing work methods and skills requirements, and placing new demands on everything from data handling to organisation and leadership. SALAR works to create the basic conditions enabling municipalities and regions to take advantage of the opportunities offered by automatisation and artificial intelligence."*

SALAR has also introduced a network for AI in municipalities and regions.[27]

Nordic Welfare Centre
The Nordic Welfare Centre is an institution within the social and health sector of the Nordic Council of Ministers. Its mission is to *"contribute to the development of welfare initiatives in the Nordic region. By compiling and disseminating knowledge on welfare issues, we offer strengthened tools for policy-making, as well as tools for improving the health and well-being of all citisens."*

The 2021 report *New technology and digital solutions for increased inclusion in working life includes a knowledge compilation, which states that: "People with disabilities have a lower employment rate compared with the rest of the population and face greater challenges in working life. Are there new technological and digital solutions that can contribute to better inclusion?"*[28]

14.2. Research funders

Government agencies and organisations that fund research conduct their own studies, publish their own reports, and produce compilations of the projects

26 https://www.do.se/om-do/pressrum/aktuellt/aktuellt-under-2020/skyddet-mot-diskriminering-behover-ses-over/
27 https://skr.se/skr/naringslivarbetedigitalisering/digitalisering/sammanhallendigitalservice/automation/natverket-foraiikommunerochregioner.32805.html
28 https://nordicwelfare.org/publikationer/ny-teknik-och-digitala-losningar-for-okad-inkludering-i-arbetslivet/

they fund. The following are some important compilations and lists of projects that are relevant to the area of AI, robotisation and the work environment:

Vinnova, Sweden's innovation agency, has a mission to *"build Sweden's innovation capacity, contributing to sustainable growth"*. Vinnova funds research and studies various questions through government assignments. Some initiatives related to AI, robotisation and the work environment are:

- A report from 2018, Artificial intelligence in Swedish business and society. Analysis of development and potential.[29]
- A compilation of Vinnova's activities in the area of AI.[30]

Vinnova has invested SEK 100 million in the organisation AI Sweden[31] for the period of 2020–2024. The organisation is a national center for applied AI research and innovation, and is divided into several geographic nodes.

> *"The purpose is to accelerate the use of AI by sharing knowledge and data, co-locating expertise, and running projects of national interest."*

The organisation Women in AI[32] has produced a report, with support from Vinnova, on "AI for gender equality" (2020).[33]

Forte[34], the Swedish Research Council for Health, Working Life, and Welfare, allocates support for research. Projects with a focus on automated decision-making in social services, among other areas, are included in their national programs for applied welfare research.

Afa Insurance funds research and development in the area of the work environment and health. A current research program supports research on the effects of digitalisation in municipalities and regions.[35]

The program contains several projects with a more obvious connection to AI, robotics, and the work environment. For example, the projects:

- *AI in the service of the bureaucracy – changing digital work environment as robot colleagues become part of everyday life (Halmstad University),*
- *From Form to Robot? A study on automation of case handling in Swedish municipalities (Linköping University)*
- *Work environment of robotic dementia care: the importance of social robots for care providers' work methods and work environment (Linköping University).*

29 https://www.vinnova.se/publikationer/artificiell-intelligens-i-svenskt-naringsliv-och-samhalle/
30 https://www.vinnova.se/m/artificiell-intelligens-ai/
31 https://www.ai.se/en
32 https://www.womeninai.co
33 https://www.vinnova.se/globalassets/mikrosajter/ai-for-jamstalldhet-starker-tillvaxten-samhallsekonomin-och-arbetsmarknaden/ai-for-genderequality-accessable.pdf
34 https://forte.se/
35 https://fou.afaforsakring.se/sv/the-research-archive/digitaliseringens-effekter-pa-arbetsmiljon-inom-kommun--och-regionsektorn

14.3. Business and industry

The Confederation of Swedish Enterprise has published a report with a connection to AI: The Confederation of Swedish Enterprise participating in Produktion2030.[36]

> *"Produktion2030 is a strategic innovation program supported by Vinnova, the Swedish Energy Agency and Formas. Its goal is to ensure that Sweden remains a competitive manufacturing nation. We will achieve this by translating industry challenges into relevant and innovative solutions; by building up and strengthening networks and collaborations, both within Sweden and internationally; and by bringing together ideas, players, and funding opportunities in order to create valuable solutions for the manufacturing industry of the future."* [37]

14.4. Labor unions

Labor union initiatives and views on AI, robotisation, and the work environment are presented in various documents. Examples include the following.

The Swedish Trade Union Confederation (LO) has expressed some basic principles relating to digital systems in the workplace. These have been put forward, among other places, in LO's response to the European Commission's proposal for AI regulation (2021).[38]

In this document, LO welcomes human-centered AI development with the user and employee at the center, based on actual needs and solutions addressing them. LO asserts that it is necessary to clarify which digital solutions are most suitable depending on the activity involved, and which steps and decisions are best done through people. The choices made and how AI systems function impact the work content, methods, organisation, and environment, and can also influence the profession itself, and how professionals view their role. LO says that digitalisation and automatisation must not occur at the expense of employees, and employees' rights must not be negatively impacted by the introduction of digital systems. LO would like to see AI contribute to a stimulating rather than skills eroding technology.

LO also believes that employees and their union representatives must be given a key role in all phases when technical systems are introduced in workplaces. The European social partners have negotiated a process description for how an employee-centered approach can be used for the whole lifecycle of digital systems. LO notes that this might be a template for the Swedish labor market

36 https://www.svensktnaringsliv.se/fraga/Artificiell_intelligens
37 https://produktion2030.se/ny-rapport-artificiell-intelligens-inom-tillverkningsindustrin/
38 https://www.lo.se/start/lo_fakta/los_yttrande_over_europeiska_kommissionens_forslag_till_forordning_om_harmoniserade_regler_for_artificiell_intelligens

to involve and place people at the center of AI. LO also believes that you must never negotiate or regulate away the status of human decisions as superior to AI.

LO participates in the AI Agenda for Sweden led by RISE. LO is a cofounder of Digitalidag[39]. LO works with employers' organisations to implement the European social partners' autonomous framework agreement on digitalisation, which includes the issue of AI. LO is also involved with the European Commission's initiative to regulate AI, and with the European Trade Union Confederation's work to regulate AI.

The Swedish Confederation of Professional Employees[40] (TCO) produces several newsletters and blogs, including this.[41]

One press release has the heading: *"TCO's board takes on the AI challenge".*[42]

Unionen[43], which organises professionals in the private sector, has published documents with a connection to technological developments and future working life. For example:

- *New technology, automatisation, and the Coronavirus crisis – changes in the professional labor market"*[44]

They also say that AI must be treated as a working life issue. "Artificial intelligence, AI, is used in more and more contexts and the technology is developing quickly. But it is not simple. Therefore the European branch of the global service sector union UNI[45] has compiled a document containing its positions on artificial intelligence."

Vision has published a vision document, Vision's direction for 2020–2024. It contains a plan for

> *"Digitalisation/robotisation – a changed working life". Among other things, it states the following on change processes and influence: "Robots and automatisation have existed in Swedish industry for a long time. New technology and new ways of organising work are also changing the conditions for work in welfare. The professional role is changing, due among other reasons to technology and automatisation. The tasks we perform today may be different tomorrow because they can be systematised or organised differently. (...) Employees are the welfare system's strongest resource. Employees must lead and carry out changes and smart solutions that can improve services for citisens, patients, and consumers."*[46, 47]

39 https://digitalidag.org/
40 https://www.tco.se/
41 https://www.tco.se/tco-bloggar/bloggare/samuel-engblom/algoritmerna-ansvaret-och-arbetsplatserna/
42 https://www.tco.se/Nyheter-Och-Debatt/Pressmeddelanden/2019/Tcos-Styrelse-Antar-Ai-Utmaning/
43 https://www.unionen.se/
44 https://unionenopinion.se/var-politik/ny-teknik-automatisering-och-coronakris/
45 https://www.uni-europa.org/topics/ai/
46 https://vision.se/
47 https://vision.se/globalassets/om-vision/forbundsmoten/2019/visions_inriktning_2020-2024.pdf

Vision has also produced a number of reports on working life applications, for example the following:

- *Robots make work more fun*[48]
- *The machine processes, she makes the call*[49]
- *Here comes your new robot colleague*[50]
- *Feminist digitalisation for a more suitable working life*[51]

The Swedish Association of Graduate Engineers writes in the document *Views of the Swedish Association of Graduate Engineers on artificial intelligence that:*

> *"Artificial intelligence, AI, is a technology that will have significant influence in many areas. The technology creates new opportunities for growth and development. Meanwhile, progress is occurring rapidly, and legislation and ethical principles are therefore at risk of failing to keep up. The members of the Swedish Association of Graduate Engineers are central to the development and implementation of AI. As a profession, we have a responsibility for use to benefit people, the environment and society, and to occur without causing harm, in line with the association's Code of Honor."*[52]

The Swedish Medical Association has a policy from 2019 entitled "Policy for digital operational support and the work environment". It contains text describing the association's view of digitalisation, requirements for digital systems, links to the work environment, requirements for decision-making support in healthcare and more. Among other things, the document states:

> *"In addition, medical expertise and physicians' time are needed to obtain fit-for-purpose functions and for future development and administration. Evidence must be required before digital solutions, like other technical methods, are introduced into point-of-care activities." "Unfortunately, the digitalisation of healthcare can also lead to a negative impact on the work environment. Digital tools that are not adapted to the activities are one of the most significant work environment problems in healthcare. Stress easily arises as a result of technology that does not work as intended; this could involve technical problems as well as administration problems. Inadequate training can cause new technology to create problems, especially at an introductory phase" as well as "Another concern is what impact decision-making support will have on the role of physicians in the future. If assessments and decisions become overly mechanical, there is a risk that less space will be given to the physician's experience, expertise, and ability to conduct a clinical evaluation. Decision-making support and AI must not be mandatory; rather, there must be space for*

48 https://vision.se/tidningenvision/arkiv/2020/nr1/roboten-gor-jobbet-roligare/
49 https://vision.se/tidningenvision/arkiv/2019/nr-4/maskinen-handlagger-hon-beslutar/
50 https://vision.se/tidningenvision/arkiv/2019/nr-4/nu-kommer-din-nya-robotkollega/
51 https://vision.se/nyheter/2020/november/feministisk-digitalisering-for-ett-battre-anpassat-arbetsliv/
52 https://www.sverigesingenjorer.se/globalassets/dokument/policy-papers/sveriges-ingenjorers-syn-pa-artificiell-intelligens-ai.pdf

individually tailored care."[53]

The Union of Civil Servants (ST) *made the following decisions at their Congress in 2020:*

"The Congress approved a program for beneficial digitalisation of society, working life, and our own organisation. Digitalisation is necessary for a sustainable government administration. This is partly so that we can provide good public services throughout the country, and so that taxes are used responsibly. Our demands involve the digitalisation of government administration taking place responsibly and in compliance with the rule of law, and starting from a citisens' perspective. This includes citisens having the right to request that a person, and not a computer, makes decisions in their cases, and the introduction of a ban on automated decisions."[54]

AKAVIA[55] writes the following in their 2021 report, The effects of digitalisation on the legal profession:

"When AI is used for legal advice, contracts, or decisions based on such databases, not only is critical thinking required, but also reflection on whether the outcome is fair, based on the context in which it will be applied," "In the future, technical solutions and AI are expected to be used increasingly as tools in legal assessments by the courts. AI solutions may simplify the process and enhance the efficiency of administrative work, but also serve as support for decision-making or sentencing," and "At the same time, all lawyers must take responsibility for their own learning and personal development, not only within IT, but also to develop their self-knowledge and abilities that AI/robots are unable to handle."[56]

14.5 Swedish and international standards

The international and Swedish standardisation organisations ISO[57] and SIS[58] have published a number of standards that are to some extent of interest in relation to AI, robotisation, automatisation, and the work environment. Many of those pertaining to AI are listed by ISO.[59]

As a part of the extensive ISO 9241[60] standard, which covers the usability, ergonomics, etcetera, of digital systems, there is one document with this

53 https://slf.se/app/uploads/2020/03/it-policy-2019-webb.pdf
54 https://www.publikt.se/nyhet/st-kraver-teknikneutral-grundlag-22718
55 https://www.akavia.se/
56 https://www.akavia.se/siteassets/01-gemensamt/trycksaker-och-broschyrer/rapport-akavia_digitaliseringens-effekter-pa-juristbranschen_2021.pdf
57 https://www.iso.org/home.html
58 https://www.sis.se/
59 https://www.iso.org/committee/6794475/x/catalogue/
60 https://www.iso.org/search.html?q=9241

designation[61]. It addresses ergonomics in a wide sense in connection with the use of robots and intelligent autonomous systems. Among other things, it states:

> *"Product development of systems with robot, intelligent and autonomous characteristics is rapidly progressing. Given the human-system issues of such systems, timely guidance covering these issues is necessary to help all sectors of industry to design, field and operate first-time quality robotic, intelligent, autonomous (RIA) systems, and build appropriate trust in products and services that use these systems.*
>
> *This document reviews the ergonomics for a range of RIA systems. It describes the human-system issues that should be considered in the application of these technologies and identification of priorities for future standardisation work. The purpose of this study is to identify and explore the ramifications of a categories of issues involving RIA systems that suggest a need to reset the boundaries of what is called ergonomics.*
>
> *This document addresses:*
> - *physically embodied RIA systems, such as robots and autonomous vehicles with which users will physically interact;*
> - *systems embedded within the physical environment with which users do not consciously interact, but which collect data and/or modify the environment within which people live or work such as smart building and, mood-detection;*
> - *intelligent software tools and agents with which users actively interact through some form of user interface;*
> - *intelligent software agents which act without active user input to modify or tailor the systems to the user's behaviour, task or some other purpose, including providing context specific content/information, tailoring adverts to a user based on information about them, user interfaces that adapt to the cognitive or physiological state, "ambient intelligence";*
> - *the effect on users resulting from the combined interaction of several RIA systems such as conflicting behaviours between the RIA systems under the same circumstances;*
> - *the complex system-of-systems and sociotechnical impacts of the use of RIA systems, particularly on society and government."*

A new, upcoming standard from Swedish SIS/TK 38062 describes a process for Ergonomics of human-system interaction – Usability assessment. It contains checklists as well as proposed processes for implementing assessments for the purpose of identifying problems related to usability and the work environment in workplaces. A minor part of the checklist covers matters related to the use of AI systems. Standardisation documents are supplied by ISO and SIS on a commercial basis.

61 https://www.iso.org/obp/ui/#iso:std:iso:tr:9241:-810:ed-1:v1:en

15. Summary of other sources of knowledge

For a professional worker in an enterprise or organisation, the work environment is composed of all biological, medical, physiological, psychological, social, and technical factors that the individual perceives and is affected by in a work situation and in their surroundings. According to such a definition, the methods used to develop the technical systems – whether they were developed using AI methods or some other way – are neither particularly interesting nor important for employees and their work environment. What is important for their experiences and their performance are the characteristics of the systems, how they function when used, how usable they are, how they are introduced, whether people have the skills to use the systems properly, whether they have good support when needed, etcetera. Thus the conclusion would be that "old" research and "old" knowledge about the work environment in relation to digitalisation and automatisation largely remains valid and can be applied to situations in which AI, robots, and other new technology are introduced into the work. At the same time, it is necessary to study whether AI and robotisation create any new conditions and risks that call for new knowledge for them to be managed. The new technologies make it possible to digitalise and automate new operations and work tasks in a way that was not previously possible. They can also intervene in tasks in greater depth, in a way unmatched by earlier technology. New possibilities along with new problems and questions arise.

The descriptions above present an assortment of knowledge produced by earlier research. Undoubtedly, this knowledge is to a large extent applicable when it is a question of understanding how new technology such as AI and robots affects people, organisations, and work tasks. Other earlier research on work environment issues is relevant as well, but may require interpretation in new terms.

This review of current research and agencies' and organisations' initiatives, investigations, and reports does not claim to be comprehensive, but describes important activities and positions. Above all, it can be seen that what players with responsibility for the work environment are demanding is not being met by current research activities. In addition, the majority of the positions taken express principles and provide no clear directives for expanded investment in the kind of work environment research that could offer new information about how to handle future work environment problems. A good work environment is a necessary condition for realising the potential benefit to the labor market of the new technologies. A few key knowledge gaps that must therefore be filled are discussed in greater detail below.

Part 4 – Discussion and conclusions

Part 4 discusses knowledge gaps that have been identified, areas that are being researched to a very limited extent, some conclusions about future research needs, and general recommendations on how to apply the knowledge in practice.

16. Discussion

The purpose of the literature review has been to describe the current state of research and knowledge regarding the impact of AI and robotisation on the work environment.

Employees' experiences and their ability to perform the work are strongly dependent on the characteristics of the technical support systems, their usability, how they were introduced, whether the person has the right skills, and whether the proper support is available when needed. The above analysis above of existing research literature and other sources of knowledge shows that the new technologies, AI and robotic systems, will affect much of this, and that many jobs and work tasks will be impacted more extensively than what was possible with earlier digitalisation and automatisation methods. It is important that the research produces applicable knowledge that facilitates an understanding of the new work environment problems that may arise and creates opportunities for preventive work. This is important if the technologies' significant potential for improvements is to be utilised, and for future jobs and professions to be made safe, efficient, and sustainable.

The analysis of the current state of research and knowledge demonstrates significant shortcomings in these respects, as work environment aspects are rarely part of the research. At the same time, there is a great deal of knowledge from earlier research on more traditional digitalisation and automatisation that has not been fully applied to the new technologies or the new jobs that are emerging.

However, the surveyed research does point to some key overarching and general conclusions about AI, robotisation, and their effects on the work environment.

Usability, transparency, and trust are important for a good work environment

The scientific literature and other sources indicate the risk of increased stress in working life, an imbalance between perceived demands and the possibility of meeting them, with the introduction of new technology. This may have several causes, such as a high workload, absence of the necessary skills or support, problems with the technology, or inadequate usability or transparency of the technical systems. The latter means that users do not understand or cannot follow how an AI system or robot functions or acts, and therefore experience a lack of control over the situation. The research shows that understanding how the technology functions, and perceiving it as supportive and useful, improves trust in autonomous systems and reduces anxiety and stress. This creates better possibilities for safe, efficient and sustainable systems and jobs.

Employee control, support, and skills have positive effects on the work environment

Several more applied research projects focus on the effects of AI and robotics on different professional groups, on their skills and experience of control and support. This research is about the perceived meaningfulness of the work and how to give employees the best conditions for doing their jobs without harmful stress. Everyone must be given the opportunity to acquire the necessary skills to feel they have mastered changed work tasks and new technical systems. As new technical systems are introduced, perceived demands will increase and in this situation the experience of control needs to be high and perceived support strong. The research points to the importance of providing the necessary skills for understanding and handling the technology, while retaining personal control.

Knowledge about the technology, how it works and how to use it, is also important for creating high situation awareness in conjunction with automatisation and robotisation. If these conditions are not in place, safety risks and work environment problems arise. Becoming dependent on technology that one does not understand, but must accept, has a negative impact on both motivation and professional skills. The human must have the conditions and ability to understand when the technology is failing and be able to take suitable action.

Ethical questions are important for the work environment

The research is unanimous that technology must be experienced as safe if users are to be able to use it effectively, to feel secure at work, and to reduce the risk of harmful stress. Safety covers several different aspects: physical safety, that the technology does what is expected of it, that data are handled safely and securely and so forth. This has a clear connection to the work environment.

However, an overarching conclusion is that the research does not currently match the needs of various players for applicable knowledge about the impact of AI and robotisation on the work environment. This is both remarkable and unfortunate.

It is remarkable because we know that the digitalisation and automatisation that have taken place to this point have extensively impacted and changed working life and the conditions for carrying out work, and have thus had a significant impact on the work environment – for better or for worse. The experiences that can be drawn from this should underscore the importance of continuing to prioritise empirical research on the work environment as a complement to more theoretical and technical research. The technically oriented projects should also more often be able to include work environment aspects in their studies. In addition, there should be space for projects that compile the results of other research and interpret them in terms of the work environment, in order to use this information to understand and prevent problems. Many of the research groups that develop methods and future applications of AI and robotisation lack knowledge about the work

environment, despite the fact that the research programs of which they are a part have instructions to consider the impact on individuals and jobs.

It is unfortunate because the future impact of AI and robotisation on the work environment will surely be at least as extensive as digitalisation and automatisation have been so far. It would therefore be valuable to have well-founded knowledge that can support future applications and facilitate a preventive work environment perspective in future technological development and work on change. If the expected effects for Swedish business and working life are to be reached, then we will sooner or later be forced to consider the effects of the new technology on the work environment.

Because a good work environment is a necessary condition for utilising the potential of the new technologies, it is important to fill the knowledge gaps and thus create conditions for good applications and the sustainable development of future jobs.

Several players in Swedish working life have clearly expressed that use of the new technologies must be viewed as a work environment issue. But this has evidently not had much of an impact on the research. More and more major investments are being made with technology at the center. The goal is often for businesses not to be "left behind", or there is an emphasis on the importance of strengthening Sweden's AI profile. To be "best in the world". But at the same time, it is emphasised that the research should support the development of theory and practice in respect of the human and societal aspects of AI and autonomous systems, with a particular focus on potential ethical, economic, labor-market-related, social, and legal aspects of the technological shift, as well as the importance of treating AI as a working life issue. Many of those in charge emphasise that the research must be interdisciplinary and that the humanities and social sciences should be combined with technology research. This should likely mean that work environment issues are and should be important.

Artificial intelligence and robotisation have enormous potential to contribute innovative improvements in several different respects, not least for working life. Organisations and businesses can be developed to have higher levels of efficiency, quality, safety, and sustainability. Brand-new solutions can be found to the problems of society and working life. Through advanced technology, jobs can be streamlined, developed, and supported in entirely new ways. There is a need for research and development that supports all of these potentially positive outcomes. Development must not result in negative effects on the work environment. A good work environment and good technological development must go hand in hand, and this requires knowledge that can be put into practice. To achieve this goal significant supplementation of current research is needed.

There is a clear, built-in problem complex between what is technically possible and what is meaningful and desirable in practice. While technology to automate decision-making is being developed quickly, some think it should be banned entirely, at least in conjunction with the exercise of public authority. The so-called Scandinavian model of digitalisation, which has been very successful and drawn international attention, could also be a model for developing and introducing AI and robots in working life. In brief, the model involves change processes taking place in collaboration between the parties, employers and employees; that it is carried out with significant user participation; and that the changes are viewed as business development, and not only as a technological shift. This will make it possible to leverage the major improvement potential of the new technologies while ensuring that everyone involved participates in the change process in collaboration, and that safety, sustainability, and a good work environment are always in focus.

17. Knowledge gaps and research needs

The surveyed research and knowledge development presented above, both in the research literature and elsewhere, clearly points to the large knowledge gaps surrounding the impact of AI and robotisation on the work environment. Existing research is primarily of a basic, technical nature, and describes methods and technology developments or discusses possible applications in the future. Some research investigates aspects of introducing and using the technology in working life, but without explicitly placing it in a work environment context. Various sub-questions are often addressed, all of which might be interesting for the work environment, but without an interpretation in terms of the work environment. There is also very little empirical research on the impact on the work environment of existing applications of AI and robotics, which makes it difficult to produce experience-based knowledge. When the studies include professional AI and robot users, there is often limited treatment of views and attitudes toward the new technology. The empirical studies that have been found also tend to focus on "third parties", that is, on customers, patients or care recipients, and not on professional practitioners. The number of empirical studies is very limited. Many of the identified publications are speculative in nature and discuss desirable or possible future scenarios – utopias or dystopias.

Nor does research in the humanities and social sciences on AI and robotics to any great extent investigate questions related to professionals in their working life and work environment. This research tends to be about, for example, sociological aspects of collaboration, expectations and behaviors of people in relation to AI and robots, processes of change in business, democracy and justice, as well as matters of ethics and effects on trust and empathy. This research contains a great deal that is ultimately meaningful for the work environment, but this is rarely made explicit or discussed.

Above all, there is a lack of applicable and scientifically based knowledge for practitioners, that is, knowledge about how one can and should proceed to, using AI and robotics, develop and introduce technical systems in a professional context with consideration of efficiency, safety, and a good work environment.

Some specific knowledge gaps that have been identified in the above survey and analysis are:

- The gender perspective and equal opportunities perspective are absent from essentially all of the analysed research. There are many important questions that would need investigating. Examples include questions about AI and social sustainability that study how AI impacts the work environment in terms of the grounds of discriminationnsuch as gender, ethnicity, religion etcetera.

Other questions include how masculinity norms affect the use of AI and robots in terms of safety. We know from other research that masculinity norms affect safety culture; perhaps that is the case here as well? How do norms related to gender and technology impact our acceptance of working with AI systems or robotic systems in healthcare? How do we design AI and robots for an inclusive working life, and how can we use AI and robots to create a good work environment and accessibility for all? Research on gender equality aspects in relation to perceived "technostress" or trust in the technology is also absent.

- There is a dearth of research addressing how skills, tasks, and routines change in the short and long term after introducing AI and robotic systems, as well as what this means for quality, effectiveness, safety, job satisfaction, and the work environment. How are skills and skills requirements affected over time? Undermined, strengthened, renewed?
- Questions related to the causes and forms of stress, such as "technostress," when working with AI systems or robots are not being studied. Important questions include whether work becomes less flexible and "porous" after introducing AI and robots, whether there are fewer breaks of the type we get when we talk to a colleague or go to get something and so forth. What is the effect on recovery time during the working day?
- There is a dearth of research addressing how the use of AI and robots affects safety in a business or organisation. If safety is to be created in a socio-technical system, that system must be studied in its entirety. One purpose of robotisation may be to improve safety, but in that case research on this aspect must also include significantly more of the human aspects and interplay between people and technology as well as the work environment that emerges. One question involves how the feeling of trust is affected by increasing reliance on AI and robots.
- There is a dearth of important empirical research on how AI and robotic systems can and should be designed to contribute to a good work environment. Examples include studies of the relationships between transparency and explainable AI (AI systems whose actions can be understood by a human) and the work environment. Similarly, there is a lack of empirical research that evaluates the introduction of AI and robotics from a work environment perspective in different industries and professions. Here, there is a need for example for cohort studies of AI and robotics in relation to the work environment and health. Experiences from the use of AI and robotic systems in working life up to this point should be studied in greater detail.
- There is extensive existing research on good change processes in conjunction with digitalisation, change management, requirements, design, development, implementation, and evaluations. However, no studies investigate whether this knowledge is relevant for AI and robotisation. Specific examples of knowledge that is needed are:
    - Which knowledge about traditional digitalisation and automatisation-related work environment issues can be transferred to AI and robotisation.
    - How the design of AI and robots impacts the work environment physically, organisationally, socially, and cognitively.

    - How to handle work environment issues when developing and introducing AI and robotic systems, best practices and pitfalls.
    - Artificial intelligence and robotisation in relation to user influence.
    - What challenges and opportunities do various work environment players, such as HR departments, occupational healthcare etcetera, encounter in an organisation when becoming involved in development and introduction?
    - What new skills do system developers in different roles need if they are to design and introduce AI and robotic systems with consideration given to a good work environment.
- The existing research on robotics and the work environment in health and medical care focuses largely on applications in surgery, mainly in the work environment of the doctors, the surgeons. The work environments of other professional groups, and in other sectors of care, are not studied as often, nor possible differences between high-status and low-status professions.
- There is a dearth of research investigating emotions related to AI, robotics, and automatisation in the work environment. Given that emotional experiences are connected to work environment issues, it would be highly relevant to study, for example, the feeling of meaningfulness at work when introducing AI and robotics.
- Research that shows connections between the individual, the organisational, and the structural levels is lacking. On the subject of trust and transparency, there is a lack of research that studies how individuals develop trust or distrust in AI systems and how this is connected to organisational culture and leadership, as well as to the way change processes are organised and led within an organisation.
- Very little research covers media portrayals of AI and robots (with some significant exceptions, see Czarniawska & Joerges, 2020), how the media treatment of studies of labor market changes, or forecasts about how some professional groups may disappear, affects how people experience their work and how meaningful and futureproof they perceive it to be.

17.1. How can the knowledge gaps be filled?

Several different players are responsible for ensuring that the knowledge gaps are filled and that practically applicable knowledge is produced about how the introduction and use of AI and robots affects the work environment. The purpose here is not to pinpoint different responsibilities, but to describe some more general measures that have been identified. Then all players with responsibility can determine their own actions. Examples of players with responsibility, of different types and at different levels, for producing and applying knowledge include EU bodies, the government, government agencies, research funders, research groups and individual researchers, employer and employee organisations, leadership and work environment managers in companies and organisations, as well as education coordinators at universities and colleges.

This survey has demonstrated a clear gap between different types of directives and how they are able to influence research. It takes time to move from overarching directives to implemented knowledge development and practical applications; this is clear and reasonable. However, more explicit steering of research through clearer language in directives and programs could have positive effects. Naturally, there is a dilemma here and it is controversial to encroach upon academic freedom and free research. But that is not what this is about; of course free research must continue and be provided with resources. But if we want to see research and knowledge development about the impact of new technologies on the work environment, this must happen via targeted initiatives.

It is clear that most of the research groups developing methods and applications of AI and robotisation in working life lack expertise about work environment issues, or alternatively, that matters related to the work environment are not included in the funded research programs. In those cases when knowledge, technology, and systems are meant to be applied in working life, the studies should include work environment issues. An alternative solution is to supplement the research with other collaborative research that focuses on effects on the work environment.

The social partners largely seem to agree that the potential benefit of AI and robotisation must be leveraged. This requires knowledge that is practically applicable, on the floor, in companies and organisations. There is also agreement that technological development must be seen as a working life issue, and a good work environment must go hand in hand with technological development. This may benefit from clearer engagement and clearer shared demands from the partners. They cannot wait for the research to produce the necessary knowledge, methods, and tools; rather, they must be a driving force.

Corporate and organisational management, the employers, have absolute responsibility for work environment issues in the workplace. A number of surveys have shown that, in the context of with traditional digitalisation and automatisation, there is often a lack of competence regarding understanding and influencing the digital work environment. Circumstances probably become even more complicated with the introduction of newer technologies, such as AI and robots. It is necessary for management and work environment managers, safety officers, HR departments, occupational healthcare services, etcetera to acquire expertise, develop functioning processes for identifying and correcting problems in the work environment, and work proactively when new developments take place.

In academic training at universities and colleges, future generations of researchers and technology developers must be taught to understand how new technology affects the work environment, and be given the skills to consider aspects of the work environment in conjunction with all development and introduction of technologies. Tomorrow's work environment experts and HR specialists also need a greater understanding of how the technology affects organisations, individuals, and the work environment. University programs currently incorporate too few of these elements.

18. How can knowledge be applied in practice?

Knowledge that is not easily applied in practice cannot contribute to good, sustainable change. Based on the surveys carried out and on earlier knowledge, we can formulate several more general recommendations for how we can and should consider aspects of the work environment when developing and introducing AI and robots in working life.

There is a great deal of knowledge and experience covering good ways to introduce traditional digitalisation and automatisation into working life, with a focus on the development of the businesses, a good introduction, a good work environment, and sustainable jobs. Much of this information and many of these methods are also entirely applicable when developing and introducing future AI and robotic systems.

The basic principles and methods for developing well-functioning, effective, usable, and safe digital systems, while considering aspects of the work environment and job sustainability, have been discussed earlier in this report, see sections 2.5, 12.1 and 12.2. A few important and well-known aspects of digitalisation and automatisation that focus on the work environment are:

- The emphasis should always be on developing the organisation and not primarily on the introduction of new technology. The long-term goals of the organisation must be made explicit and guide the change process.
- Usability and a good digital work environment can never be added later; they must be considered from the start and incorporated into all phases of change.
- It is essential to have good change management, with an understanding of work environment issues, as well as good change processes.
- Those in charge of the technological development, such as project initiators and technology developers, must understand the effects on the work environment and work with management as well as future users.
- A well-functioning, user-centered development model, in which future users are involved in all phases of the change process, is a precondition for participation, acceptance, and good usability.
- The work environment must be seen holistically, with consideration of the employees' entire situation and surroundings, and not only relative to individual digital systems.
- The introduction of a new or modified digital system is a critical phase of change. You are always introducing a new job, and not just a new technical system. Training and support must be based on this and be available before, during and after the introduction of the technology.

- A lifecycle perspective on the change process is important. A digital system needs to be regularly evaluated and developed further, which must be part of the plan from the beginning.
- The organisation must have established processes, allocated responsibilities and resources for the continuous evaluation of the digital work environment and for taking necessary corrective measures when needed. One method of doing this is to introduce digital safety audits, IT safety audits. The focus should be on business benefit, usability, and a good digital work environment. Collaboration is required among roles with different responsibilities: management, work environment departments, HR departments, local employee organisations, safety officers, occupational healthcare, those in charge of technological development, IT departments, initiators of IT systems, etcetera.

One important question is what changes when the digital development involves not just traditional digitalisation and automatisation, but new technologies, such as AI and robotisation. What new considerations, principles, processes, and methods become important and necessary to apply? A few such changes were discussed earlier in this report. It primarily relates to the fact that new industries, professions and jobs will be affected, and jobs will be impacted in somewhat different and perhaps more thorough ways than before. Jobs that were digitalised before, primarily through support from administrative systems, will be affected on a more fundamental level, for example by being equipped with new decision-making material, or through the introduction of fully automated decision-making systems. Technical systems will transition from only being supportive, to becoming more or less autonomous. Jobs that used to be carried out completely manually, even if with digital support, will be automated. However, in essentially all of these new situations, humans and technology will continue to need to interact. The jobs and their support systems must therefore be seen from a socio-technical perspective. Knowledge and methods of taking account of effects on the work environment and of creating sustainable jobs also in these new situations must be developed and applied.

There is a significant lack of knowledge about AI, robotisation, and automatisation from a work environment perspective, and about how to apply them. The importance of supplementing the extensive technical research that is currently available about AI and new forms of robotisation with work environment aspects must therefore be emphasised. Before such information is available, it is difficult to provide specific recommendations for how it should be applied. However, in general and based on earlier research, the following recommendations can be given in addition to what is stated above.

- It is important to have a socio-technical perspective on the organisation, the activities, the individuals and the technical change work. What is developed and introduced should be a well-functioning whole, consisting of people in various roles in collaboration with digital systems that are often more or less autonomous.

- The perspective of the organisation becomes especially important. What are its goals, and how are they supported by the introduction of AI or robots? Does the new technology benefit the organisation?
- Questions regarding what is possible to automate, what is desirable to automate, and how this impacts the operation, safety and work environment must be analysed before changes are initiated.
- Technology often leads to changes to professional roles and skills requirements. The technology intervenes in work processes more extensively and changes the conditions for how they can be carried out; therefore, not only the technology, but also the new jobs must be carefully designed. This necessitates clear and well-established goals as well as extensive skills development. An important aspect to keep in mind is how professional skills may be impacted in the long-term. What becomes vulnerable?
- Various safety aspects become important. How do we create resilient systems (see section 12.4) in the relevant organisation? There must be methods in place for risk analysis and incident investigation. A good safety culture and good leadership regarding safety issues will be crucial.
- Because the new technology affects work conditions more extensively, questions about people's trust in it must be given consideration. There is a need for transparency of the technology, new skills and good processes for development and implementation.
- Automatisation of work processes is always complex. Good knowledge is required about automatisation, opportunities and pitfalls, principles for good collaboration between humans and automatic systems, as well as how this affects quality, safety, and the work environment.
- Ethical aspects must be given consideration, for example when entirely new questions related to responsibility and decision-making arise.
- Legal questions related to legality, responsibility, safety, privacy, etcetera must be addressed.
- New kinds of questions related to equal opportunities arise and must be handled. Who develops the technology and on whose terms? Does any bias, systematic distortion, arise in the technical systems that renders them inadequate when it comes to equal treatment?
- People in various roles who have responsibility and who will be active in the process of change must have the necessary skills, especially an understanding of how AI and robotisation affect the organisation, jobs, skills, safety, and the work environment. This requires established processes for lifelong learning in organisations.

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Appendix 1 – Included articles. The individual perspective.

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Appendix 4a. Search results. The individual perspective

Search date: 20201217 & 18 Search period: 20100101–20211231

Keywords Search field Limitations	Number of hits
Business Source Complete	
#1 TI ("Artificial intelligence" OR AI OR "Computerized intelligence" OR "Computational intelligence" OR Robot* OR "Machine learning" OR Automation OR "Neural network*" OR "Deep learning" OR "learning algorithm*" OR "intelligent algorithm*")	11,634
#2 TI "Occupational health" OR Work-environment* OR Occupational* OR Work* OR "Work-related stress" OR "Occupational stress" OR Stress OR "Job demand*" OR Technostress OR "ICT demands" OR Ergonom* OR Motivation OR Expertise OR "social support" OR Education OR Discriminat* OR skills	54,801
#3 #1 AND #2	306
Medline	
#1 Artificial Intelligence + OR Robotics+	69,972
#2 Ergonomics+ OR Occupations+ OR Employment + OR Workplace OR Occupational Stress OR Occupational Diseases OR Motivation OR Occupational Health	134,206
#3: #1 AND #2	1,314
Psycinfo	
#1 "Artificial intelligence" OR ai OR "Computerized intelligence" OR "Computational intelligence" OR Robot* OR "Machine learning" OR Automation OR "Neural network*" OR "Deep learning" OR "learning algorithm*" OR "intelligent algorithm*"	7,797
#2 "Occupational health" OR Work-environment* OR Occupational* OR Work* OR "Work-related stress" OR "Occupational stress" OR Stress OR "Job demand*" OR Technostress OR "ICT demands" OR Ergonom* OR Motivation OR Expertise OR "social support" OR Education OR Discriminat* OR skills	133,284
#3: #1 AND #2	**299**
TOTAL	
Total number of articles from searches	**1,919**
Total number of relevant articles (after sorting)	**103**

Appendix 4b. Search results. The organizational perspective

Search date: 20201217 & 18 Search period: 20100101–20211231

Keywords Search field Limitations	Number of hits
Business Source Complete	
#1 TI ("Artificial intelligence" OR AI OR "Computerized intelligence" OR "Computational intelligence" OR Robot* OR "Machine learning" OR Automation OR "Neural network*" OR "Deep learning" OR "learning algorithm*" OR "intelligent algorithm*") Limiters - Scholarly (Peer Reviewed) Journals; Published Date: 20100101-20211231; Publication Type: Academic Journal; Document Type: Article; Language: English Expanders - Apply equivalent subjects Search modes - Find all my search terms	11,634
#4 TI Organization OR "organization* culture*" OR "organization* design*" OR management OR leadership OR decision-making OR "knowledge management" OR "organization* control" OR "organiz* change" OR "organization* development" OR secur* OR privacy OR safety OR "organization* power"	79,887
#5 #1 AND #4	**407**
Medline	
#1 Artificial Intelligence + OR Robotics+	69,972
#4 Work Simplification OR Organizational Culture OR Organizations + OR Leadership OR Knowledge OR Workforce + OR Organizational Innovation+	138,602
#5: #1 AND #4	650
Psycinfo	
#1 "Artificial intelligence" OR ai OR "Computerized intelligence" OR "Computational intelligence" OR Robot* OR "Machine learning" OR Automation OR "Neural network*" OR "Deep learning" OR "learning algorithm*" OR "intelligent algorithm*"	7,797
#4 Organization OR "organization* culture*" OR "organization* design*" OR management OR leadership OR decision-making OR knowledge- OR "knowledge management" OR "organization* control" OR "organiz* change" OR "organization* development" OR secur* OR privacy OR safety OR "organization* power"	66,685
#5: #1 AND #4	**206**
TOTAL	
Total number of articles from searches	**1,263**
Total number of relevant articles (after sorting)	**71**

Appendix 4c. Search results. The structural perspective

Search date: 20201217 & 18 Search period: 20100101–20211231

Keywords Search field Limitations	Number of hits
Business Source Complete	
#1 TI ("Artificial intelligence" OR AI OR "Computerized intelligence" OR "Computational intelligence" OR Robot* OR "Machine learning" OR Automation OR "Neural network*" OR "Deep learning" OR "learning algorithm*" OR "intelligent algorithm*"	11,634
#6 TI Law OR norm* OR institution* OR media OR discriminat* OR power OR field* OR privacy OR "labor market" OR ethic* OR employ*	101,865
#7 #1 AND #6	**519**
Medline	
#1 Artificial Intelligence + OR Robotics+	69,972
#6 Jurisprudence OR International Law OR Discrimination, Psychological OR Social Discrimination+	13,536
#7: #1 AND #6	**76**
Psycinfo	
#1 "Artificial intelligence" OR ai OR "Computerized intelligence" OR "Computational intelligence" OR Robot* OR "Machine learning" OR Automation OR "Neural network*" OR "Deep learning" OR "learning algorithm*" OR "intelligent algorithm*"	7,797
#6 Law OR norm* OR institution* OR media OR discriminat* OR power OR field* OR privacy OR "labor market" OR ethic* OR employ*	64,872
#7: #1 AND #6	**231**
TOTAL	
Total number of articles from searches	**826**
Total number of relevant articles (after sorting)	**34**

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