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HOW DO WE HANDLE COMPUTER-BASED TECHNOLOGY? WHAT IS THE COST/BENEFIT RATIO OF TECHNOLOGY FOR WORKERS?

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Overview

This chapter focuses on the question of how to deal with technology. Technology has changed our life, it has changed how we communicate with each other, and how we work, and also when and where we work. It is important to understand how and why it has changed our life, and what kind of consequences this has. Technology may affect our (mental) health and well-being. In this chapter we present an overview of factors that need to be taken into account when designing technology. First, a historic perspective is presented in order to understand the development of technology in the work context. Technology at work is generally believed to help us, but this is not always the case. Technology can also make work complex; it can also lead to health problems, in particular when wrong decisions are made while designing technology. A core issue is to what extent people are still in control of technology. The main question is to understand how individuals are affected by technology at work, and know how technology should be handled.

20.1 Introduction

A work situation without computer-based technologies is unthinkable nowadays. The term computer-based technology applies not only to Information and Communication Technology (ICT), such as email and the internet, but includes all kinds of artefacts that people use. The range of applications varies from 'simple' technology such as personal computers, or infusion pumps that are used to administer medicines, to large-scale automated systems in advanced socio-technical systems such as cockpits in commercial jets, control rooms in nuclear power plants, or to perform robotic surgery. In general, people will agree that technology can have great advantages in terms of increased production, accuracy of work and safety. For instance, air traffic would not be possible on the present scale without technology. On the other hand, technology has also changed the nature of work for those people who have to use these systems; it has made work much more complex and has created new types of health problems. Whereas originally musculoskeletal problems due to a static working posture received most attention, nowadays the focus is more on psychological health issues, like frustration and anger when the technology does not 'behave' as expected, and also mental fatigue, boredom, or stress are currently important issues. This raises a number of important questions: How do individuals handle these issues? What are the options for dealing with, or avoiding, these problems? What are the advantages and disadvantages of technology for organizations and for the individual? What is the cost/benefit ratio in terms of well-being at work? In order to answer such questions, we need to have an understanding of the origin of the problems. This will be the main focus of this chapter.

People's fascination with new technology has often obscured their insight that technology transforms both work and workers. Understanding how new technology affects people is important when knowing how to design and use future technology, and technology-based work. A historic perspective may help an understanding of how the relationship between human and machine has developed and how this has changed both work and the workers. This chapter will describe the development of technology (for a brief summary of various phases see Box 20.1), and will outline some of the consequences of using technology at work and the risks they may entail for workers' health. Furthermore, we will explore several ways to humanize the impact that technology may have on work environments of the future.

BOX 20.1: THE FIVE PHASES OF TECHNOLOGY CHANGE

1. Mechanization: This reflects the period until approximately the 1960s, in which machines were primarily used to replace human muscle power, where simple and repeating operations were required. In particular, agriculture and industry were mechanized. As a consequence, many jobs disappeared in the agricultural sector.

2. Automation: The 1970s and 1980s were characterized by automation: technology had advanced and features such as coordination and timing of various activities could be included which allowed the series of simple operations to be connected to form more complex operations in the production process. In this period the first computers were introduced into offices, and office automation began.

3. Computerization: The microchip allowed programming of operations, and thus building and applying algorithms ('if *x*, then y') in clearly defined situations. The implication was that machines could also make (simple) 'decisions' and become an 'agent' in the work process. The rapid development of microchips allowed more powerful and faster computers to be built that were connected so that they could communicate with each other and exchange data.

4. 'Robotization': When in the 1980s the microchip was introduced, more complex operations could be programmed into more autonomous machines, and consequently robots could help to realize very precise operations such as in robotic surgery or even handle large parts of the process, for example, in car manufacturing or in aviation.

5. Information and communication technology: Around 1990, the development of ICT facilitated the sharing of information between all kinds of parties: colleagues, but also customers and suppliers. It made the transfer of information much faster, which was particularly useful for people working at a distance but, in turn, transformed the way people communicate with each other.

20.2 Mechanization, Automation and Robotization: Technology as a Substitute for Workers

During the Industrial Revolution (around 1880) in Britain, production changed from craftsmanship, based on skills and expertise, to large-scale mass production based on standardization, quantity and mechanization. The English philosopher Adam Smith (1723-1790) published his work On the Wealth of Nations (1776), in which he propagated the principles of a 'free market' and the 'division of work' as leading principles for society. A more rational division of work would lead to specialization and hence to the improvement of skills, and consequently more efficient production. A number of years later, the English mathematician Charles Babbage (1791-1871) applied those principles to a cognitive activity: mathematical work. He divided mathematical work between 'mathematicians' who developed algorithms, and 'senior workers' who translated the algorithms into work procedures, and 'calculators' who had to apply those procedures to make simple calculations. In this way a rather complex activity (calculating) was divided into a series of operations that varied considerably in complexity. The 'mathematicians' were responsible for the most complex work, and the 'calculators' had the simplest work. As a consequence, not every employee had to be equally educated and skilled, which meant that not all employees earned the same wages (the 'calculators' were much cheaper to employ). After having applied this principle of 'splitting up complex work' into a sequence of simpler operations, the next step was that Babbage developed a machine that could perform those simple operations (which he called 'the Difference Engine' in 1853 and this is considered to be the forefather of programmable computers), and the machine that took over the work of the 'calculators'.

In the USA, Frederic Taylor (1865-1915) built further upon these ideas. Where Babbage introduced the division of work, which caused a shift in job content, Taylor added the principle of division of 'head labour' and 'hand labour', now known as 'Taylorism'. This further reduced the influence workers had over how they would do their own work. It resulted in simple and monotonous work and reduced the worker to a 'mechanical instrument', which further excavated the role of workers in the work process. In the USA, Henry Ford (1863-1947) applied these principles and added another element resulting in 'the assembly line'. Whereas previously groups of employees moved from one spot to the next work spot to assemble cars, Ford introduced that the cars would move through the hall, and the workers would stay at their own spot. This imposed a certain speed of work on people, and restrained workers even further. Because work was increasingly 'simplified' and 'dismantled', the ultimate consequence was that it could be taken over by automated systems and 'robots'.

From that point, the human operator's main role was to supervise the automatic process. Sheridan (1987) used the term "supervisory control" to describe the new roles of humans at work in relation to this development. These supervisory roles include: (1) planning what tasks to do, and programming the computer, (2) on-line monitoring of the automatic actions to make sure all is going as planned, (3) detecting failures, and (4) intervening in case of surprises or unanticipated situations (1987, p. 1248). This applies to large-scale processes in the chemical industry, nuclear power plants, healthcare, aviation and many other work settings. Airplanes are nowadays 'flown' by their computers in most phases of flight, during which pilots monitor the situation and make decisions about a suitable course of action, and then program the computers to do it and oversee the adequate functioning of the systems. Only in specific phases of flight (such as 'take-off') or when incidents occur, such as technical failures, do they need to fly the airplane manually. Usually, mode changes (transition from one automatic control logic to another one) are initiated by the human operator. However, in advanced technological systems, mode changes can also be the result of system input. For example, in aviation, the pilot can initiate a transition of mode by entering a command to the computer-system, but it can also be initiated by the system itself, for instance, when the system detects that the airplane has reached a certain prescribed altitude, or if the pilot is putting the plane into an unsafe configuration. This illustrates that the functions (or roles) are not allocated to either the human or to the automated system, as recommended by the famous Fitts' list (1951, see Table 20.1), but is a result from the interaction between the two, where both have to operate as a 'team player' (Klein et al. 2004). This increases the complexity for users and necessitates monitoring the joint performance of the operator and the automated system. And this can easily create a mismatch between what the pilot observes and what the pilot expects to see, if the indirect input on the process is not detected or known. Woods and Hollnagel (2006) use the term 'automation surprise' to describe the 'miscommunication and miss-assessment' between the user and the automated system, which leads to a gap between the user's understanding of what the automated systems are set up to do, what they are doing, and what they are going to do' (pp. 120-121).

The Fitts' list (1951) proposes a list of 11 statements to guide the allocation of functionality based on whether the machine or the human operator performs the task better. The list is reproduced in Table 20.1. Since then, the Fitts' list has received a lot of criticism, including that the list does not take into account aspects like dynamic allocation, contextual variations and the psychological needs of humans at work (job satisfaction, motivation, psychosocial aspects, stress) (Hancock, 2009; Winter & Dodou, 2014).

Table 20.1: *Fitts' list (Fitt, 1951, p°10) as quoted by Winter & Dodou (2014).*

Humans appear to exceed present-day machines with respect to the following:	Present-day machines appear to exceed humans with respect to the following:
1. Ability to detect a small amount of visual or acoustic energy	1. Ability to respond quickly to control signals and to apply great force smoothly and precisely
2. Ability to perceive patterns of light or sound	2. Ability to perform repetitive, routine tasks
3. Ability to improvise and use flexible procedures	3. Ability to store information briefly and then to erase it completely
4. Ability to store very large amounts of information for long periods and to recall relevant facts at the appropriate time	4. Ability to reason deductively, including computational ability
5. Ability to reason inductively	5. Ability to handle highly complex operations, i.e. to do many different things at once
6. Ability to exercise judgment	

20.3 Technology as a Tool

Technology aims to make our job easier, more effective or more efficient. It is used at work either: (1) to replace the human, or (2) to circumvent certain limitations that human beings have, or (3) to extend the capabilities of humans beyond what they can achieve alone. Computers are particularly good examples of the latter: they are much better at storing information and making calculations than humans. However, over the years accumulated research has shown that interaction with automated systems do not always make the job easier. Weiner (1989) noted that automation can actually increase the workload. Wickens (1999) suggested that extensive use of automation may cause an operator's manual skill to deteriorate, or even disappear, because the worker becomes a mere passive bystander, or observer, instead of an active participant. For this particular reason, various professions have rules that people in that profession must spend a minimum amount of hours per year practising their skills. Several physiological and subjective reports suggest that vigilance tasks reduce task engagement and increase distress (Miller, 2012). For instance, Johansson and Aronsson (1984) demonstrated that workers who had no control over the pace of their work reported more psychological health complaints (i.e., feelings of depression, apathy, feelings of anxiety and unhappiness, low levels of self-confidence, negative self-image, etc.). Another study (Ekkers, Brouwers, Pasmooij, & Vlaming, 1980) found that, in highly automated systems, operators spent only 2.6% of their time on 'operating' the system and reported low levels of achievement and job satisfaction. Generally, their level of well-being appears to be low and sickness absence relatively high. Furthermore it appears that the difficulty of the task, and poor leadership practices (i.e., unfairness, etc.) are positively correlated with mental health complaints and fatigue.

The level of control that operators have in their work is largely determined by the 'level of automation'. Sheridan and Verplank (1978) described ten levels of automation in man-computer decision-making. The lowest level represents manual systems in which the human operator does the whole job up to the point of turning it over to the computer. At the highest end of the spectrum are fully automated systems in which the computer does the whole job, when it decides it should be done. Between these two extreme situations automation varies in terms of authority' and 'autonomy'. At the lower levels of automation, computers might offer suggestions for the user to consider, whereas at the higher levels of automation computers might have the authority to select and execute an action, and then inform the human operator.

An important consequence of this technological development is that a distance is created between the production process and the human operator. There is no longer direct contact with the process itself: the process is represented via information that can be read from displays. Thus 'information' becomes the critical object of work (i.e., 'information work'). This physical distance also leads to a psychological distance. The computer interface serves as a window on the complex process, providing operators with a 'mediated representation' of the process in order to allow them to form an adequate mental model of the process. Operators cannot use their own sensory organs (smell, vision, audio, tactile) to follow the process, but depend on information provided by the interface. Thus, there is a strong need to provide workers with appropriate information and representations of the process, which leads to questions such as: Which information is effectively used by human operators during work? How to represent and integrate this information in meaningful ways on displays? Anyone that has ever looked into the cockpit of a modern airplane immediately understands what is meant here. As a result, the demands of work have become largely cognitive (information processing) demands.

Mental workload has become a critical ergonomic criterion for designing and assessing technology. It can be described as 'the relation between the mental capacities that are demanded by a task and the capacities that can be made available by the human operator' (Parasuraman, Sheridan, & Wickens, 2008, pp. 140-160). Researchers have argued that automated systems can leave the operators with too little to do and consequently operators are exposed to boredom, sleepiness, hypo-vigilance and attention slips. On the other hand, operators can also be confronted with unexpected events or failures of the system which require immediate action. In these situations the operator needs to know as soon as possible what the problem is, and what actions are needed. These situations are often very challenging, and constitute a high mental workload, because the operator may have lost a detailed awareness of the situation during the automated phases. In aviation, this has been described as 'falling behind the plane', or as 'losing the bubble' (Woods, Johannesen, Cook, & Sarter, 1994), meaning that the operator has lost his/her internal representation (mental model) of the dynamics of the process.

Bainbridge (1987) referred to this phenomenon as 'the irony of automation': , human operators increasingly lose their basic skills because they no longer practise their skills, as their activity is taken over by automated systems in daily operations, but yet they are expected to demonstrate superior skills when they occasionally have to take over from computers in unexpected, surprising, or difficult, and very stressful situations.

These issues have prompted 'human-centred' automation concepts, which aim to improve the relationship between users and automated systems, and look for design solutions that allow 'adaptive automation' that would match the level of automation with the level of operator workload (Scerbo, 1996; Parasuraman et al. 2008).

20.4 Computerization, Information & Communication Technology (ICT): Technology Supporting Workers

The process of 'rationalization' of work processes that we described above, started in industrial settings, but later also spread to offices and the service industry. Tayloristic principles were also applied in the office sector (cognitive Taylorism). As a consequence, specialized typing and data-entry departments, and call centres were created (Braverman, 1974; Carayon & Smith, 2000) that operated 24 hours a day and were located in low wage countries. Increasingly also, in offices, machines would dictate how people would have to do their job (think of writing a letter with paper and pencil, compared to a word processor). Modern ICT devices, like word processors, smartphones, tablets, have spelling checkers, word suggestions, and other features such as standardized sentences that are meant to facilitate writing letters or emails. It can become very confusing for recipients of messages to assess whether the message came from a human being or from a machine. Machines are programmed with rules and the logic of the machine is often imposed on people, constraining creativity and originality (Besnier, 2012). At the same time, people become increasingly dependent on these technologies that are more and more embedded into our environment. Who nowadays can still remember telephone numbers, since they are stored in the memory of one's mobile phone?

The fact that computers are connected to each other and can be used to communicate has resulted in what we now know as the 'world wide web'. That has introduced new ways of communicating with other people, but has also changed the way we communicate with each other.

People nowadays send emails more frequently and more easily than they make phone calls. This is partly because a phone call requires the receiving party to be 'available' to talk. Such 'synchronous interaction' is not required with email (i.e., 'asynchronous interaction'), or other communication devices (i.e., 'whatsApp'). As a consequence, communication between people is mostly 'mediated communication' (i.e., communication via a device as opposed to 'face-to-face'). This has advantages, because asynchronous interaction leaves the message until the recipient has time to read, but it also makes it much more difficult to capture the 'richness' of face-to-face communication (facial expressions, emotional tone, etc.). Therefore mediated communication can easily lead to misunderstandings: that is why increasingly people use so-called 'emoticons' in their messages. Sometimes people think that when an email has been sent, it automatically means that the information is received, read and understood. Since email can be fast, people often expect a quick reply, and people may even feel pressed to respond quickly. A delayed response may also be interpreted as a 'signal', maybe expressing 'disinterest' in the message or sender. An email can also be sent to many recipients at the same time, which has introduced a 'strategic dimension' to communicating with email. People use the 'carbon copy' (cc, or blind cc) to send emails to inform several people at the same time (and the bcc is used to inform others in secret). In addition email can be sent 24 hours a day, and thus transgresses the traditional boundaries between working time and family time. The result is that a lot of information is distributed to a lot of people at all time. Increasingly people find it difficult or problematic to handle and filter the information they receive, hence the term 'information overload' has been introduced. Some people have problems handling this continuous stream of information and become addicted to checking their email, or webpages, because they are afraid of missing out on important information. It also means that many people are constantly connected to work, and may start becoming anxious about work (Cropley & Zijlstra, 2011). In both cases this may lead to severe mental health problems.

Recently, companies have started developing protocols for better use of ICT technologies like: not checking work mails after 20:00 hours and at weekends, reducing the number of emails using the 'cc option', thinking about which type of message fits best with what kind of medium, and avoiding emailing a colleague two doors down the corridor but rather go and talk to that person, etc. These protocols aim to regulate the interaction with machines, and try to stimulate people to be aware of how to use the technology and also stimulate some self-reflection in this respect. This may place some constraints on human-machine interaction, emphasizing self-management and self-authority by prescribing how to use particular devices outside the domain of work. For instance, professional mobile phones can be switched off, so that employees are no longer contactable 24 hours a day.

The availability of information in the public domain has increased enormously thanks to the internet (or the 'world-wide web'), probably even more than most people are aware of. This adds to the information overload, but also constitutes other issues that the general public is not aware of. For instance, organizations also use social media. It has been estimated that internet recruitment is the second largest source of income for providers (Maynard, 1997). This can have an impact on employees, job applicants, the selection process and organizations. People are not always aware that Facebook profiles and other information (pictures and news items on websites) that are available on the internet are used by organizations to screen job applicants. All kinds of undesirable or negative information (even on websites by others) are available and can be used. There are examples when people have lost their jobs because of their postings on Facebook or

Twitter, which were done in the spur of a moment, without much thought. This makes it even more important to control the information that is available, and to filter information and decide what information is relevant or not. Electronic harassment has become a phenomenon in the social domain, but happens also in work settings (Griffiths, 2002). People can be bullied and stalked with (hate)-mail, or 'pictures' or other private content that is distributed using email or social media.

The impact of the technological evolution on workers is different, depending on the content of their work. Aronsson (1989) observed differential effects for higher, middle and lower level skilled employees: the lower-skilled employees reported a substantial increase in intensified work and job dissatisfaction, whereas the higher-skilled employees reported no changes in their tasks (the middle group was somewhere in between). About 95% of lower level skilled workers expected that their work would be made redundant somewhere in the next five years. Aronsson believed that the explanation for the differences in effects between various groups could be found in the fact that higher-skilled employees (often managers) were more involved, and thus had more influence over decisions regarding what technology would be bought or developed. And thus they benefit more from technology, and consequently have less complaints and more satisfaction (Burkhardt & Brass, 1990). Women appear to have more complaints than men (Lindström, 1991), which could also be explained by the fact that women often have lower-level jobs than men.

Taking the development of the relationship between humans and machines into account, Hancock (2009) foresees three different roles for humans in the future of technology: humans as Masters, Servants or Slaves of the machine.

Hockey (2003) developed a model describing the various modes of control, the subjective states of the operator and the consequences for performance, and effort. This model can be adapted and linked to the different levels of automation and the roles of human operators as perceived by Hancock (2009) in order to predict consequences of automation for workers' health. These are presented in Table 20.2. The 'engaged mode' might correspond to a human-machine system in which the human operators control the machine and understand what is going on. In this role, they can maintain optimal performance while exerting effort, resulting in satisfaction and well-being at work. The 'strain mode' corresponds to a human-machine system in which the machine dictates the boundaries and the constraints of the work. In this interaction pattern, the human operators become the servants of automation. They can maintain nominal performance, but only with increasing effort, anxiety and chronic fatigue. The 'disengaged mode' might correspond to a fully automated system where the human operators are kept into the task loop to maintain or supervise the automated process, but have no control over the machine. Under these conditions, the operators may lower or even abandon the goals of the task. Consequently performance will decline while causing high levels of stress, depression and feelings of anxiety for the operator.

***Table 20.2:** Levels of automation, roles of human and expected effects on workers' health*

Role of human in the technology based environment	*Environmental context*	*Human control mode*	*Performance*	*Affective State*

Human as Master of machine	High demands high control	Engaged	Optimal	Effort without distress Anxiety 0 Effort + Fatigue -
Human as Servant of machine	High demands low control	Strain	Adequate	Effort with distress Anxiety + Effort + Fatigue +
Human as Slave of machine	Low demands low control	Disengaged	Impaired	Distress without effort Anxiety + Effort – Fatigue 0

(Source: Adapted from Hockey, 2003 and Hancock, 2009)

20.5 Trust in Technologies and Acceptance

An important factor that will determine how people will handle a technology depends on the level of trust people have in technology (Hancock, Billings, & Schaefer, 2011; Parasuraman, et al., 2008). Trust in technology is the result of an adequate match between the user's observation of the 'behaviour' of technology and the user's inference about the technology's intent or its performance. With new technology people are sometimes a little sceptical, and wonder: 'Will it function properly? Will it be quicker than how we did it before?' (Are response times consistent, or sometimes long?). But there are also other questions that relate more to their own position: 'How will it affect my job?', 'Will I still have my job in two years' time?', 'Will I be able to work with the technology' People's perceptions concerning the potential answers to these questions will determine how they will accept the new technology.

Lee and Moray (1992) conducted pioneering research showing that an operator's use of automation to control a simulated plant was directly related to his/her momentary trust, which in turn was related to the type and frequency of the technology's failures. Low level of trust can lead to not using the system, but it can also make people feel either insecure or frustrated. On the contrary, high levels of trust can be associated with being over-reliant on the system and disregarding other relevant information. Think of using your car navigation system, while the signs along the road suggest that you should take another route. Which system do you trust more, and what information will you follow?

More recently, Hancock, Billings, Schaefer, Chen, de Visser, and Parasuraman (2011) conducted a meta-analysis to better understand the antecedents of trust in technology. They quantified the effects of human-related factors (e.g., demographics, propensity to trust, self-confidence), robot-related factors (e.g., reliability, predictability, level of automation, transparency) and environmental-related factors (e.g., culture, communication, task type) on perceived trust in robots. The robot's performance and attributes were the largest contributors to the development of trust. The human and the environmental factors were found to be only weakly associated with trust.

Yet, the human characteristics (e.g., gender, age, level of experience) have an impact on the overall perception of technology and, consequently, determine how humans might engage with technology. For instance, elderly teachers worry about whether they will be able to keep up with the digitalization of teaching materials in schools, and the changing role of the teacher in this process. They see young children coming to school, for whom Ipads and computers have no surprises, whereas some teachers have just learned how to 'swipe'. With the increasingly rapid evolution of technology, there is danger of creating a divide between technology savvy workers who can easily learn and adapt to using new technology and those for whom technology will always remain a 'closed book' (Hancock, 2009, p. 97).

This indeed is becoming a huge issue, since technology is used in many different economic sectors, and systems have become more and more 'intelligent', and 'self-learning'. Artificial Intelligence has developed so far that machines can beat humans at the most complex board games, like Chess and Go. Technology (robots) is now also considered to be used in the care sector, and the first hotels that are completely based on self-service have emerged. These systems rely completely on intelligent technology. The current debate focuses on whether these increasingly 'intelligent' systems will take over other types of work in the service sector as well, as is demonstrated by the development of self-service cashiers in supermarkets, or therapeutic robots for elderly people in the healthcare sector. For that reason some people are referring to the 'Second Machine Age' (Brynjolfsson & Mcafee, 2014), suggesting that new technologies might make more and more people redundant.

As already cited, Hancock (2009) has asked the very relevant question in terms of well-being at work: to what degree are humans still masters of the machine, rather than servants or slaves?

20.6 Conclusion

In this chapter, the effects of technology on workers' health and well-being in different domains have been presented. Technology can support workers and reduce the workload and stress, but it can also do just the opposite when it is badly designed and deployed. The negative consequences are often much greater than would ever be possible in the non-automated state.

The recent literature on stress-related disorders and psychosocial risks in the workplace explains the pervasive impacts of technology. Having autonomy and being in control over work are two important factors relating to well-being at work, and in particular these aspects are at risk when dealing with technology. With these observations in mind, the conclusion should be that in order to deal with technology, people should be given, or made aware of, the autonomy and control options they have when dealing with technology. And system designers should also look at the psychosocial risks that might potentially loom for human beings. This is the only way to guarantee that humans and machines will be able to work together amicably.

Thus far, system designers have largely focused on functionality and system reliability. Several researchers have presented a user-centred design approach (Billings, 1997; Nyssen, 2004; Vicente, 1999; Woods & Hollnagel, 2006) that involves prospective users in the design process in order to better identify the needs and constraints of the users in the context in which the system should be used. Hancock (2009) goes one step further and points to the need to construct a philosophy of technology that examines the moral dimensions of the design process and the use of technology by exploring the notion of 'intention' and 'freedom' in the future human-machine system environments. In this line of reasoning we should not make systems that constrain people and reduce humans to servants or slaves by forcing people to follow the pace and the operations dictated by machines, but researchers and designers should promote innovative design solutions that support autonomy, choice and adaptation. Such a design philosophy will be beneficial to the reliability and resilience of the human-machine system, and good for the development and well-being of workers.

Summary

In this chapter we have examined the development of technology and its effects on workers in different work domains (industry, office, services) from automation to ICT. We are often very fascinated with what new technology has to offer, and that is why we often are blind to the fact that technology transforms both work and workers. We have explicitly emphasized the impact technology can have on workers' well-being: their workload, fatigue and psychosocial risks, by relating the level of automation to the concept of workers' autonomy and control over work. Our intention throughout the chapter has been to provide an overview of current research which aims to improve the interaction between users and their automated environment. Our viewpoint is that we should look for ways of designing adaptive automation, which takes the dynamic nature of the users' needs and constraints in work environments into account. It is our hope that this chapter illustrates that system design is a multidisciplinary effort between experts in human behaviour and engineers. Designers and users should have a broad interest regarding the consequences of technology and ensure that design process takes these aspects into account.

Discussion Points

1 Imagine that you are in a position to order high technology equipment for your organization, which of the issues addressed in this chapter would you find most relevant to take into account in your decision-making process?

2 What kind of tasks can be taken over by machines? And try to think of what the consequences would be for the 'operator', but also for the 'recipient'. Make a list of tasks in the healthcare sector, the service industry, and logistics.

Suggested Further Reading

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies.* New York: W.W. Norton & Company, Inc. This book will help you think about what the consequences might be when technology adopts an even more important role in our society.

Hancock, P. A. (2009). *Mind, machine and morality: Toward a philosophy of human-technology symbiosis.* Farnham: Ashgate. This book examines the potential dangerous paths of technology and asks questions about the role of the human operator in man-machine relationships.

Hockey, R. (2013). *The psychology of fatigue: Work, effort and control.* Cambridge: Cambridge University Press. This book explains how we can understand fatigue, and the many aspects of fatigue - mental, physical, sleepiness - and their influence on performance and well-being at work.

Norman, D. A. (2011). *Living with complexity*. Cambridge, MA: MIT Press. Norman describes how poor design solutions can make life very complicated.

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