Artificial Intelligence:
Occupational Safety and Health and the Future of Work

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1. Introduction

Artificial intelligence (AI) was born, or at least its name was, in 1956, at a series of academic workshops organised at Dartmouth College in New Hampshire, where a group of scientists set out to teach machines to use language, form concepts, improve themselves (as machines), and solve problems originally 'reserved for humans' (McCarthy et al. 1955). John McCarthy and his colleagues had high hopes that they could achieve this within a few weeks. The conference was not successful on its own terms, but nevertheless, a significant field of research and development in AI was launched.

We might now laugh at this optimism. Nonetheless, interest in AI did not disappear. AI debates and experimentation have gone through a series of phases, from the peak of hope that machines could be trained to behave exactly like people and achieve an equivalent level of intelligence to humans, as seen at the Dartmouth workshops, to the troughs of disillusionment. The first robot experiments such as WOBOT and Shakey, while innovating, did not achieve universal AI (discussed in *What is AI?* below). Two so-called AI winters lasted 1974 – 1980 and 1987 – 1993 as various experiments failed and funding waned. But now, in 2019, a revived interest is bubbling.

Nowadays, advanced countries are allocating significant pots of funding in the billions to research and development in AI, with US in the lead and China and Israel in close second (Delponte 2018). AI is predicted to provide a 26 per cent boost to GDP by 2030 in China. North America is predicted to see a 14.5 per cent boost (PwC 2018a), and some predictions indicate that AI will create as many jobs as it eliminates (PwC 2018b). Consultancies' and thinktanks' forecasts run alongside a series of governmental, regional and international organisations' high level reports which predict the impact of AI on economies and societies including the United States of America (White House 2018), the United Kingdom's Department for Business, Energy and Industrial Strategy and Department for Digital, Culture, Media

and Sport (2018), the International Labour Organisation of the United Nations (Ernst, Merola, Samaan 2018), and the European Union (European Commission 2018).[i]

The current EU-OSHA report looks at the use of AI enhanced tools and applications in workplaces, looking at where and how this is occurring and what the implications are for of workers' occupational safety and health (OSH). To identify this, the report outlines where and how AI is being applied in the workplace, covering a series of applications and tools now used for workplace decision-making, in human resources (HR) via people analytics and interview filming; AI augmented robotics including collaborative robots (cobots) and chatbots; the uses of wearable technologies and assistive tablets on the production assembly line; and algorithmic processes in gig work. Each section outlines the benefits and risks that AI present for OSH at work. Then, the report suggests worker training and outlines government and international responses to the rising risks and benefits to AI at work. In conclusion, the report provides some recommendations for how to best manage and mitigate the worst risks that could arise with AI in workplaces.

2. **What is AI?**

There is debate today about 'what is AI' and 'what is not AI'. It could even appear today that there is more hype around AI than reality. Nonetheless, as governments are pouring huge amounts of capital into research and development and publishing high-level reports making notable predictions about the contributions that AI will make to GDP and productivity, it is worth taking AI seriously. The dispute around the authenticity of AI is relevant, however. So, rather than waver throughout the current report on definition, the original discussion about what AI 'could be', is recalled. McCarthy and his colleagues defined the 'artificial intelligence problem' as one that 'is taken to be that of making a machine behave in ways that would be called intelligent if a human were so behaving' (McCarthy et al. 1955). Since the authors of the Dartmouth document invented the concept of AI, recalling their definition lends much to the discussion. Can machines behave like humans, and if so, *why* do we want them to? These philosophical questions are not extensively dealt with in this article, but it is worth noting that these ideas fed into this research areas' early incarnations (see e g. Simon 1969; Dreyfus 1972; Weizenbaum 1976) and still work in the background of AI experimentation and application today.

Now, while there are a number of current definitions of AI, for the purposes of this report, McCarthy's definition will be used as a general insight to locate the issues epistemologically. However, the European Commission's definition as provided in a recent Communication is central, where AI 'refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals' (EC 2018). A recent report entitled 'European

[i] Given the very recent introduction of AI enhanced tools and applications into workplaces including the use of people analytics and other HR applications, there is very little data available evidencing the risks and benefits for OSH that these new techniques may produce. Several consultancies, thinktanks, IT companies and other organisations as well as government departments have produced reports on AI in the workplace that provide data which can be considered for the most part, reliable and useful within its own remit, but again, without extensive longitudinal data, much of what is being claimed is based on speculation.

Artificial Intelligence leadership, the path for an integrated vision' further defines AI as a 'cover term for techniques associated with data analysis and pattern recognition'. That report, which was requested by the European Parliament's Committee on Industry, Research and Energy, differentiates AI from other digital technologies in that 'AI are set to learn from their environments in order to take autonomous decisions' (Delponte 2018, 11). These definitions facilitate a clear discussion about what is at stake as AI systems and machines are integrated into workplaces and have competences that allow decision making and prediction much faster and more accurately than humans, allowing human-like behaviour and assistance for workers.

There are varied levels of AI now discussed by experts: weak and strong. Strong AI is also linked to the concepts of general and universal AI (see Hutter 2012). Weak AI is where a machine relies on software to guide investigation and responses. This type of AI does not reach a level of consciousness or full sentience as such, but acts as a problem-solver within a specific field of application. Weak AI thus applies to expert systems and text and image recognition. Strong, or even universal AI, on the other hand, is present when a machine can demonstrate behaviour that equals or exceeds the competence and skill of humans, and this is the type of AI that intrigued researchers such as Alan Turing the most. Even before McCarthy and his colleagues' conference in 1956, in 1950, Alan Turing had asked himself, 'can machines think' (Turing 1950)? The seemingly universal competences demonstrated by a robot such as walking, seeing and talking, could lead to universal AI, or the invention of a single universal agent that can learn to behave optimally in any environment. Today, universal AI is now becoming increasingly likely and could complete the automation process, where robots become as good at working as people, but do not exemplify human characteristics like tiredness or sickness, and so on, as computer memory capacity increases and programmes become more sophisticated. As documented below, people appear to feel more comfortable with weak AI, where it can enhance machines, robots and computers to become more like assistants to humans, rather than altogether replace us as workers or to replace human management.

3. AI in the Workplace

While there are significant possibilities for workplace progress, and growth in productivity, there are also many ethical questions arising as AI is integrated into workplaces. Namely, stress, musculoskeletal difficulties, discrimination, heightened precarisation, and the possibilities for work intensification as well as job losses have been documented as risks to psychosocial as well as physical violence in digitalised workplaces (Moore 2018a). These risks are exacerbated when AI augments already existing technological tools for workplace management and design. AI exaggerates OSH risks in digitalised workplaces because it can allow for increased monitoring and tracking, and thus, can lead to micro-management, a prime cause of stress and anxiety. AI stresses the imperative for more authority to computation, prediction machines, robotics and algorithmic processes at work.

One Eurobarometer survey indicates that Europeans are concerned about the influence of new technology on employment, where 74% expect more jobs to

disappear than appear. 44% of those surveyed stated that an aspect of their own jobs could be done specifically by AI (European Commission 2017b). But another recent survey by Gartner (Rayome 2018) of more than 2,700 workers in the US and the UK shows that 52 per cent of those surveyed would prefer AI in the workplace that would serve as an on-demand helper rather than as a manager, co-worker or proactive assistant. Indeed, AI taking the place of a physical boss could bring new sources of psychosocial hazards (Stacey et al 2018, 90). But, if applied in appropriate ways, workers also believe that AI could improve safety, help reduce mistakes and limit routine work (Rayome 2018).

It is not technology in isolation which creates benefits or risks for workers. It is instead the *implementation* of technology which creates negative or positive conditions. In that light, the current report discusses the implementations of AI enhanced technologies, discussing how they function and could become even more functional. As AI in the workplace is a relatively new area of experimentation, and companies usually do not publicly share details of internal trials and practices that incorporate AI, there is little data available indicating exactly how much and where it is being used. The data and reporting that *do* exist, both about company usage and states' and corporate investment cited throughout the present report, demonstrates that AI is not simply a fad. Trade unions, works councils, safety and health organisations and training bodies have begun to ask a range of ethical and OSH related questions that reflect a significantly different future for work.

The best known and most widespread examples of AI in workplaces are human resource applications; cobots in factories and warehouses; chatbots in call centres; wearable technologies such as HoloLens used for on-the spot-training on the assembly line; and platform applications enabling 'gig work'. Within each section, the risks and benefits of these areas of AI at work are outlined.

3.1. AI in Human Resources

Monitoring, tracking and predicting worker behaviour using office computer systems is a growing HR practice in 2019 which is seen across two areas of HR responsibility. The first, 'personnel management', is where payroll is managed, contracts are written and processed, and healthcare and other benefits are provided. The second is in 'business execution' where HR is concerned with hiring the right people and ensuring that new employees fit and contribute to the organisation's goals and strategies.

In the area of HR business execution, one increasingly popular area is called people analytics, defined broadly as the use of big data and digital tools to 'measure, report and understand employee performance, aspects of workforce planning, talent management and operational management' (Collins, Fineman and Tsuchida 2017). Computerisation, data gathering and monitoring tools, allow organizations to conduct 'real-time analytics at the point of need in the business process ... [and] allows for a deeper understanding of issues and actionable insights for the business' (ibid.). Also called 'human analytics',' talent analytics', and 'human resource analytics', this application of AI-enabled tools is defined broadly as the use of individualised data about workers and job candidates to help management and HR professionals make decisions about recruitment and in worker appraisals. For example, people analytics are used to make decisions about who to hire; to make predictions about candidates

and new hires, such as how good they will be doing their jobs; as well as how likely they are to quit on the basis of data analysis. People analytics are also used to look for patterns *across* workers' data, which can help management spot trends for example, in attendance, staff morale, or health issues. This method is also used to make judgements about existing workers' performance and used for decisions about promotions and to select future leaders.

Companies are embracing the people analytics trend, where one recent study shows that 32 per cent of personnel departments in tech companies and others, are redesigning organisations with the help of AI to optimise 'for adaptability and learning to best integrate the insights garnered from employee feedback and technology' (Kar 2018). 40 per cent of HR functions in international companies are now using AI applications. These companies are mostly based in the USA, but some European and Asian organisations are also coming on board.

Big data has been seen as a lucrative growth area for some years, where the collection of information about everything, all the time, has been an attractive investment. Now, the big data era is paying off in HR circles, because the extensive pools of data now available can be used to train algorithms to form analyses and make predictions about workers' behaviour via machine learning and assist management decisionmaking. On the basis of the patterns identified, AI enables an algorithm to produce solutions and responses to enquiries about patterns across data, much more quickly than people could do. Machine learning responses are often unlike those that a human alone would, or perhaps even could, generate. Data about workers can be gathered from various sources both in and outside of the workplace, such as keyboard clicks, information from social media, number of and content of telephone calls, websites visited, physical presence, locations visited outside the workplace via GPS, movements around the office, emails, and even tone of voice and bodily movements (Moore 2018a, 2018b).

Not all people analytics have to be, strictly speaking, AI. However, programmes' intelligent responses to algorithmic equations allow machine learning, which generate predictions and ask associated questions, which emerge without human intervention except at the data-input phase, are AI in the sense of the EU's definition above. A PwC survey shows that more and more global businesses are beginning to see the value of AI in supporting workforce management (PwC 2018a). A recent IBM report (IBM 2018) shows that half of Chief Human Resources Officers identified, anticipate and recognise the potentials for technology in HR surrounding operations and the acquisition and development of talent. A Deloitte report shows that 71 per cent of international companies consider people analytics a high priority for their organizations (Collins, Fineman and Tsuchida 2017), because it should allow organisations to not only provide good business insights but also deal with what has been called the 'people problem' (ibid.). 'People problems' are also called 'people risks' (Houghton and Green 2018), which are outlined into seven dimensions in a Chartered Institute for Personnel Development (CIPD) report as:

-talent management,
-health and safety,
-employee ethics,
-diversity and equality,

-employee relations,
-business continuity and
-reputational risk. (Houghton and Green 2018)

At first glance, it appears that AI-enhanced HR practices can help managers to learn objective wisdom about people even before they hire them, as long as management has access to data about prospective workers. People analytics tools should allow management to make unbiased predictions, conduct talent management simultaneously to protecting business health. Ideally, people analytics tools will aid employers to 'measure, report and understand employee performance, aspects of workforce planning, talent management and operational management' (Collins, Fineman and Tsuchida 2017). The use of algorithmic decision-making in people analytics processes should *mitigate against* OSH risks and support workforces by aligning employee performance feedback, impact of performance pay and workforce costs, business strategy and employee performance (Aral et al 2012, cited in Houghton and Green 2018, 5). Based on the original definition of AI, where machines are predicted to have the capability to behave as a human would do: if humans are discriminating and ourselves, biased, then we should not be surprised when AI provides biased answers. In other words, machine learning only operates on the data that it is fed, and if the data reveals past discriminatory hiring and firing practices, then the results of the algorithmic process are likely to also be discriminatory.

People analytics rely on what are effectively, *prediction machines*. Prediction machines should empower managers to make predictions in recruitment and to track, help and manage worker engagement areas, which involve issues around diversity; pay equity; retention risk; succession pipeline reporting, or identifying successive leaders for a company; and of course, recruiting metrics. All these practices should allow sophisticated insights about the bigger picture in the workplace such as when to hire more people, any emerging evidence of health issues across workers, and even to identify how well hiring consultancy sources are (Starner 2017). One CIPD report (Houghton and Green 2018) refers to 'actionable insights' obtained from people analytics data that can be used to deal with what is referred to as people problems and risks, as quoted above. 'Actionable insights' could be, for example' if a pattern in data indicates the rise in absences and changes in measured productivity in a workplace across workers or individual worker. 'People problems' could, of course, lead to judgements about 'who to fire' or decisions on 'who not to promote' and the like. If the information gathered about workers is not buffered with qualitative information about individuals' life experiences and worker consultation, unfair judgements could be made (see below). So even though prediction machines reside in a 'black box' (Pasquale 2015), people are quite happy for computer programmes to e.g. make 'prediction by exception' (Agarwal et al 2018). Prediction by exception refers to processes whereby computers deal with large data sets and are able to make reliable predictions based on routine and regular data, but also to spot outliers and even send notifications to people, 'telling' them that checks should be done and that human assistance should be provided. In this case, humans become like a resource for machines, i.e. the power relationship is reversed, where human behaviour is triggered by machinic activity rather than the other way around.

Arising OSH issues can be spotted by identifying trends and patterns not only across data collected about one individual but about data across individuals, as is enabled by people analytics software. Workers should be empowered through having access to new forms of data that help them to identify areas of improvement, stimulate personal development and achieve higher engagement. However, if processes of algorithmic decision-making in people analytics do not involve human intervention and ethical consideration, this human resource tool could expose workers to heightened structural, physical and psychosocial risks and stress. How can workers be sure decisions are being made fairly, accurately and honestly, if they do not have access to the data that is held and used by their employer? OSH risks of stress and anxiety arise if workers feel that decisions are being made based on numbers and data they have no access to nor power over. This is particularly worrying, if people analytics data leads to workplace restructuring, job replacement, job description changes and the like. Overwork as well as reduction in paid working time and significant job losses, could result, depending on which routes are selected. For example, if workers know their data is being read for talent spotting or for deciding possible layoffs, they may feel pressured to advance their worker performance, and overwork. People analytics are likely to increase workers' stress if data is used in appraisals and performance management without due diligence in process and implementation, leading to questions about micromanagement and feeling 'spied on'. Another risk arises with liability, where companies' claims about predictive capacities may later be queried for accuracy or personnel departments held accountable for discrimination.

There is a growing arena of research that demonstrates that discrimination is not eliminated by AI in decision-making and prediction. On the contrary, codification of data perpetuates the problem (Noble 2018). Importantly, AI can only learn from data that is already there which is inputted via the algorithm's designer. In other words, if bias and discrimination have already happened in a workplace over time (e.g. men are paid more than women, white men have held more management positions over time, disabled applicants are not invited for interview, etc.), data will demonstrate imbalance and even discrimination, so AI decisions can only be made based on the predominance of data types. Therefore, training AI on existing data sets will not eliminate the problem of discriminatory decision-making. Risk assessments are already being experimented with in criminal systems where AI informs sentencing and parole boards and IBM has recently publicised a tool that intends to lower these risks. These types of initiatives are hoped to work to deal with rising risks for OSH in AI assisted human resource decision-making.

One worker liaison expert indicates[ii] that worker data collection for decision-making such as seen in people analytics has created the most urgent issues arising with AI in workplaces. Often, this expert indicated, works councils are not aware of the possible uses of such management tools. Or, systems are being put into place without consultation with works councils and workers. Even more OSH risks arise, such as worker stress and job losses, when due process and diligence have not been carried out to mitigate risks, where the implementation of technologies is done in haste and without appropriate training, nor communication. Indeed, one project run at the headquarters of IG Metall is reviewing workplace training curricula, and findings are

[ii] Dr Michael Bretschneider-Hagemes, Head of the Employees Liaison Office of the German Commission KAN spoke to the current author for an interview for this report 18/09/18.

demonstrating that training needs updating in the context of *Industrie 4.0*[iii] to prepare workers not just for physical risks, but also mental and psychosocial risks that digitalisation at work introduces (see section 5).[iv]

Another form of people analytics involves the filming of job interviews, which is carried out by some organisations including Nike, Unilever, and Atlantic Public Schools. These companies are using products that allow employers to interview candidates on camera where AI is used to judge both verbal and nonverbal cues. One such product is made by a group called HireVue and is used by over 600 companies. The aim is to reduce bias that can come about if for example an interviewee's energy levels are low, or if the hiring manager has more affinity to the interview based on similar e.g. age, race and related demographics.

With regards to this typ of micro-filmed biotracked interviewing of employee candidates, evidence has already emerged that preferences from previous hiring managers are reflected in hiring, and heterosexual white men are, a report by Business Insider reveals, the hiring preference *ceteris paribus* (Feloni 2017). If data provided to an algorithm reflects the dominant bias reflected over time, then it may score someone with 'in group' facial expressions higher and rate other cues tied to sexual orientation, age and gender that do not resemble a white male, lower. So, the algorithm should be subject to a lot of testing before it is used, or the algorithm should be designed to eliminate biases, which is not an easy task. Indeed, the strength of AI is also its weakness.

3.2. Cobots

We can picture the scene: huge orange robot arms in factories whirring away in expansive warehouses in industrial landscapes, building car parts and assembling cars where conveyor belts lined with humans once stood. Robots have directly replaced workers on the assembly line in factories in many cases, and sometimes, AI is confused with automation. Automation in its pure sense involves, for example, the explicit replacement of a human's arm for a robot arm. Lower skilled, manual work has historically been most at-risk and is still at a high risk of automation. Now, automation can be augmented with autonomous machine behaviour or 'thinking'. So, the AI dimension of automation reflects where workers' brains, as well as their limbs, may no longer needed. Now, as one EU-OSHA Review on the Future of Work regarding robots and work indicates, while robots were at first built to carry out simple tasks, they are increasingly enhanced with AI capabilities and are being 'built

[iii] *Industrie 4.0* is a much debated term that originated in German manufacturing circles, designed to advance manufacturing in marketing terms. Some critics argue that it is a narrative rather than a reality today. Nonetheless it is commonly accepted that, if there is to be a trajectory of industrial revolutions, Industrie 1 is the term for the first industrial revolution and thus the invention of the steam engine. The second is linked to science advancements and the third, to digitalised inventions as incorporated into production. Today, 'internet of things', where machines technically communicate with another, advanced robotics and increased capacity for memory and processing power are seen as the driving force for the concept of *Industrie 4.0*.

[iv] Antje Utecht who works in the training and policy department at the headquarters of IG Metall in Frankfurt, Germany, shared these insights with the current author during an interview for this report 16/10/18.

to think, using AI' (Kaivo-oja 2015). Cobots can now assist with an increasing range of tasks, rather than automating entire jobs, as we will see here.

Amazon has 100,000 AI augmented cobots, which has shortened the need for training workers to less than two days. Airbus and Nissan are using cobots to speed up production and increase efficiency. Many companies are integrating robots onto the shop and factory floor to assist and collaborate with workers. The EU-OSHA 'Foresight on new and emerging occupational safety and health risks associated with digitalisation by 2025' European Risk Observatory Report (Stacey et al 2018) indicates that robots allow people to be removed from dangerous physical work and environments with chemical and ergonomic hazards (89). One expert[v] in AI and work discussed the potential benefits of AI sensors and algorithmic tools in the workplace specifically to identify dangerous situations for humans. However, IoT also introduces many challenges for safety, where machine-to-machine connected systems lead to questions about businesses' liability. Sensors, software and connectivity can be faulty and unstable, and its vulnerabilities introduce questions about who is legally responsible for any damage that emerges. Data-input problems, inaccuracies and faults with cobots therefore all create significant OSH risks.

Cobots are being integrated into factories and warehouses where they work alongside people in a collaborative way. On the one hand, cobots can reduce OSH risks as they allow AI systems to carry out mundane and routine service tasks in call centres and factories which historically create stress, overwork, musculoskeletal difficulties and even boredom of repetitive work for people. On the other, AI-augmented robots in factories and warehouses create stress and a range of serious problems if they are not implemented appropriately. Indeed, one UK-based trade unionist indicated that digitalization, automation, and algorithmic management, when 'used in combination… are toxic and are designed to strip millions of folks of basic rights'.[vi]

As a recent TNO report states, the OSH risks in human - cobot - environment interactions are as follow:

a) Cobot risks. Machine learning can lead to unpredictable robot behaviour which can lead to incidents like robot/human collisions.
b) Security risks. Robots' internets links can affect the integrity of software programming, leading to vulnerabilities in security.
c) Environmental risks. This is about sensor degradation, unexpected human action, unstructured environments. (TNO 2018: 18-19)

Potential OSH issues may also include psychosocial risk factors if people are driven to work at a cobot's pace (rather than the cobot working at a person's pace); and collisions between a cobot and a person.[vii]

AI-permitted pattern and voice recognition and machine vision mean that not only non-skilled jobs are at risk of replacement, but now, a range of non-routine and non-

[v] Based on current author's interview in September 2018 with Dr Sam Bradbrook, specialist in the Health and Safety Executive's Foresight Centre in Great Britain.
[vi] Interview with Maggie Dewhurst of the Independent Workers of Great Britain (IWGB) in 2017.
[vii] Interview with Dr Sam Bradbrook as cited above.

repetitive jobs can be carried out by cobots and other applications and tools. In that light, AI-enhanced automation enables many more aspects of work to be done by technology (Frey and Osborne 2013). One example of the protection of workplace OSH via AI is found in a company that makes optical parts for machines. The miniscule chips that are produced need to be scanned for mistakes. Previously, one person's job was to detect mistakes with their eyes, sitting in front of a repeated images of chips. Now, AI has fully replaced this task. The OSH risks, which have now been of course, eliminated, include human eye strain and damage.[viii]

Human-robot interaction creates safety risks in the physical, cognitive and social realm, but cobots should be able to reason and must make humans feel safe. To achieve this, cobots must demonstrate perception of objects versus humans, ability to predict collisions, behaviour adaptability, sufficient memory to facilitate machine learning, and decision-making autonomy (TNO 2018, 16). Another case of machine/human interaction which creates new working conditions and OSH risks, is where one person is assigned to 'look after' one machine and is sent notifications and status updates about machines on personal devices like a smart phone or a home laptop. This can lead to risks of overwork, where workers feel responsible to take note of notifications in out-of-work hours, where a work life balance is disrupted.[ix]

3.3. Chatbots

Chatbots are another AI-enhanced possibility which can deal with a high percentage of basic customer service queries, freeing up humans working in call centres to deal with more complex questions. Chatbots work alongside people though not only in the physical sense, as they are implemented to deal with customer queries over the phone in call centres. For example, Dixons Carphone uses a conversational chatbot now named Cami which can respond to first level consumer questions on the Curry website and through Facebook messenger. Insurance company Nuance launched a chatbot named Nina to respond to questions and access documentation in 2017. Morgan Stanley have provided 16,000 financial advisers with machine learning algorithms to automate routine tasks.

Call centre workers already face extensive OSH risks because of the nature of the work, which is repetitive and demanding and subject to high rates of micro-surveillance and extreme forms of measure (Woodcock 2016). An increasing number of activities are recorded and measured in call centres. Words used in emails or stated vocally can be datamined to determine workers' moods. Facial expressions likewise can be analysed to spot signs of fatigue and moods that could be used to make judgements

Chatbots, while designed to be assistive machines, still pose psychosocial risks around fears of job loss and replacement. Workers should be trained to understand the role and function of workplace bots and to know what their collaborative and assistive contributions are.

[viii] Information obtained from interview with Antje Utecht (fn 4).
[ix] Interview with Antje Utecht as cited above.

3.4. Wearables and AI at work

Wearable self-tracking devices are increasingly seen in workplaces, for example since 2014–19, an increase of 13 million fitness devices are expected to become incorporated into workplaces. The market for wearable devices in industrial and healthcare wearables, is predicted to grow from USD 21 million in 2013 to USD 9.2 billion by 2020 (Nield 2014). From 2014–19, more than 13 million wearable fitness tracking devices were predicted to be incorporated into workplaces (ibid.). GPS, RFID and now haptic sensing armbands such as the one patented by Amazon in 2018, have entirely replaced the use of clipboards and pencils for warehouse workers.

One new feature of automation and *Industrie 4.0* processes where AI-enhanced automation is underway is in the area of lot size manufacturing,[x] which is a type of lean manufacturing strategy increasingly adopted. This process involves cases where workers are provided with glasses with screens and virtual reality functionality, like HoloLenses and google glasses, or computer tablets on stands within the production line which are used to carry out on the spot tasks in production lines. The assembly line model has not disappeared, where a worker carries out one repeated, specific task for several hours at a time, but the lot size method in manufacturing is different. Used in lean manufacturing strategies, this method involves smaller orders made within specific time parameters, rather than constant bulk production that does not involve guaranteed customers. Workers are provided with visual on-the-spot training enabled by a HoloLens screen or tablet and carry out a new task which is learned instantly and only carried out for the period of time required to manufacture the specific order a factory receives. While at first glance, these assistance systems may appear to provide increased autonomy, personal responsibility and self-development, but that is not necessarily the case (Butollo, Jürgens and Krzywdzinski 2018).

In lot size manufacturing, the use of assistive tablets or small computer screens that provide specific and tailored instruction for specific orders, means that workers need less pre-existing knowledge or training and carry out the work case by case. The risk of work intensification also arises, as head-mounted displays or tablet computers become akin to live instructors for unskilled workers. Workers do not learn long term skills but instead are required to perform on-the-spot, modular activities needed to build tailor-made items. While this is good for efficiency and production, lot size methods have led to the significant OSH risks in that that it deskills workers, where skilled labour is only needed to design the on-the-spot training programmes used by workers who no longer need to themselves, specialise. OSH risks can further emerge because of the lack of communications, where worker won't be able to comprehend the complexity of the new technology quickly enough and particularly if they are also not trained to prepare for any arising hazards. One real issue is in the area of small businesses and start-ups, which are quite experimental in the use of new technologies, often overlook ensuring safety standards are carried out before accidents occur, when it is of course, too late.[xi]

[x] Interview with Dr Michael Bretschneider-Hagemes as cited above.

[xi] Prof. Dr Dietmar Reinert, PEROSH Chairman, Institute for Occupational Safety and Health of the German Social Accident Insurance, indicated this in an interview with the current author (13/09/18),

A ‘quantified workplace’ corporate wellness experiment was carried out by one company in the Netherlands with a mixture of wearable devices and other tracking technologies. During the course of the year the project ran, the employer provided professional employees, who worked as consultants and designers, with FitBit devices to monitor steps, heartrate and sleep; and RescueTime, which tracks productivity, composition and other activities when working on a computer. The employer indicated that the intention behind the experiment was to identify worker traits such as stress, which would be identified via the patterns in sleep data. Experiment participants were also asked to ‘lifelog’, or to answer a workday email that asks about subjective productivity and stress levels. The current author was funded by the British Academy/Leverhulme to interview and run surveys with participating employees throughout the project, to research their experiences of being tracked, where data was collected and stored at all these levels. Findings showed that participants, over the course of the year, grew increasingly sensitive to issues around privacy. Employees also reported a rise in workloads, as they were experiencing a merge and acquisition with a smaller company into a larger one, and researchers linked this to the decision to integrate new ways of working and the rationale for stress level monitoring. The experiment’s findings call into question whether the new tracking practices of corporate wellness programmes could be used to substitute or divert management attention away from the very risks these same technologies and working conditions create.

In an interview conducted on 16/10/17, the current author spoke with coordinators and leaders of the IG Metall Better Work 2020 project (Bezirksleitung Nordrhein-Westfalen/NRW Projekt Arbeit 2020). Trade unionists interviewed indicated that they are actively speaking to companies about the ways they are introducing *Industrie 4.0* technologies into workplaces. The introduction of robots and worker monitoring, cloud computing, machine-to-machine communications, and other systems, have prompted those running the IG Metall project to ask companies: What impact will these changes have on people’s workloads? Is work going to be easier or harder? More stressful? Will there be more (or less) work? These trade unionists indicated that stress levels tended to rise when technologies are implemented without enough training or worker dialogue. Expertise is often needed to mitigate risks of dangerous circumstances that new technologies in workplaces introduce. Next, we turn to another arena where AI is making an impact, in ‘gig work’ environments.

3.5. **Gig work**

‘Gig work’ is obtained via the use of online applications (apps), also called platforms, made available by such companies as Uber, Upwork, or Amazon Mechanical Turks. The work can be performed online (obtained and carried out on computers in homes, libraries and cafés for example, such as translation and design work), or offline (obtained online but carried out offline, such as in taxi driving or cleaning work). Monitoring and tracking have been daily experiences for couriers and taxi drivers for many years, but the rise in gig workers carrying out platform-directed cycled food delivery, delivery drivers and taxis, is relatively new. Uber and Deliveroo require workers to install a specific application onto phones which perch on respective vehicle dashboards or handlebars, and through the use of mapping satellite technologies and matching algorithmically operated software to link clients to workers.

Algorithms match passengers with drivers in offline gig work, and clients with workers in online gig work. Not all algorithms utilise AI, but the data produced by client/worker matching services and customer assessment of platform workers provide data that train profiles which then result in overall higher or lower scores that then lead e.g. clients to select specific people for work over others. In China, Didi, the ride hailing service that works like Uber, uses AI facial recognition software to identify workers as they log on to the application. One platform called BoonTech uses IBM Watson's AI Personality Insights to match clients and online gig workers such as those gaining contracts using Mechanical Turks and Upwork.

In gig work, workers have been forced to act as self-employed workers, losing out on the basic rights that formal workers enjoy such as guaranteed hours, sick and holiday pay and the right to join a union. Gig workers' online reputations are very important because this is the way they gain more work. As mentioned above, digitalised customer and client ratings and reviews are key to developing a good reputation and these ratings determine how much work gig workers get, and algorithms learn from such data to produce specific types of profiles for workers that are usually publicly available. However, customer rankings are deaf and blind to the consideration of workers' physical health, care and domestic work responsibilities, and circumstances outside workers' control which might affect their performance. Delivery gig workers are held accountable for their speed, number of deliveries per hour and customer rankings, in an intensified environment that has been proven to create OSH risks. One UPS driver told Harper's magazine that the employer uses new digitalised tools as a 'mental whip', noting that 'people get intimidated and work faster' (The Week, 2015). Drivers and riders are at risk of deactivation from the app if their customer rankings are not high enough or they do not meet other requirements. These produce OSH risks of blatant unfair treatment, stress and even fear.

There are further issues of discrimination related to women's domestic responsibilities when they are also carrying out online gig work at home, such as reproductive and caring activities in a traditional context. A recent survey of online gig workers in the developing world conducted by ILO researchers shows that a higher percentage of women than men tend to "prefer to work at home" (Rani and Furrer 2017, 14). Rani and Furrer's research also shows that 32 per cent of female workers in African countries have small children, and 42 per cent in Latin America. This results in a double burden for women, who 'spend about 25.8 hours working on platforms in a week, 20 hours of which is paid work and 5.8 hours considered unpaid work' (ibid., 13). The survey shows that 51 per cent of women gig workers work during the night (10 pm to 5 am) and the evening (76 per cent work from 6 pm to 10 pm), which are 'unsocial working hours' according to the ILO's risk categories for potential work related violence and harassment (ILO 2016, 40). Rani and Furrer further state that the global outsourcing of work through platforms has effectively led to the development of a 'twenty-four hour economy … eroding the fixed boundaries between home and work … [which further] puts a double burden on women, since responsibilities at home are unevenly distributed between sexes' (2017, 13). Working from home is already a are potentially risky environment for women who may be subject to domestic violence alongside the lack of legal protection provided in office-based work. Indeed, 'violence and harassment can occur … via technology that blurs the lines between workplaces, "domestic" places and public spaces" (ILO 2017, 97).

D'Cruz and Noronha (2016) further present a case study of online gig workers in India, where 'humans-as-a-service' (as articulated by Jeff Bezos) is critiqued for being the kind of work that dehumanises and devalues work, facilitates casualisation of workers and informalises the economy. Online gig work relies on non-standard forms of employment (46). Online gig work also allows the possibilities for child labour, forced labour, and discrimination. There is also evidence of racism, where clients are reported to direct abusive and offensive comments on the platforms in often hidden ways. Inter-worker racist behaviour is also evident, gig workers working in more advanced economies blame Indian counterparts for undercutting prices (ibid.). So there are clear risks of OSH violations in the area of discrimination, racism, bullying, and even the possibility of child and forced labour due to the lack of basic protections in these working environments.

As a method of governance, digitalising non-standard work such as home based online gig work and taxi and delivery services in offline work, leads to the quantification of tasks to a minutely granular level, meaning that it may be the case that only explicit contact time is paid, but may not lead to formalization of a labour market in the ILO sense. In terms of working time, preparatory work e.g. for reputation improvement and necessary skills development is unpaid. Surveillance is normalised but stress still results. These methods of management lead to intensified self-management and algorithmic reputation building, where customer satisfaction rankings are prioritized but can be used for such things as "deactivation" of taxi drivers, as is done by Uber, despite the paradox and fiction that algorithms are absent of "human bias" (Frey and Osborne 2013, 18).

The benefits of using AI in gig work could be passenger protection such as in the case of facial recognition mentioned above, where Didi uses it to ensure identities of drivers which is seen to be a method for crime prevention. However, there was a very serious recent failure in the use of the technology when a driver managed to log in as his father one evening, and under the false identity, later in his shift, killed a passenger. OSH protections for workers are scarce in these working environments and the risks are many (Degryse 2016; Huws 2015); and involve low pay and long hours (Berg 2016), endemic lack of training (CIPD 2017), and a high level of insecurity (Taylor 2017). Williams-Jimenez (2016) warns that labour and occupational safety and health laws have not adapted to the emergence of digitalized work and other studies are beginning to make similar claims (Degryse 2016).

Having outlined where AI is entering the workplace and the benefits and risks for OSH, the report now turns to look at responses from the wider OSH community, identifying the policy developments, debates and discussions underway on these topics.

4. Policy developments, debates and discussion

The emergence of AI and in particular the ecosystem and features of autonomous decision-making require a 'reflection about the suitability of some established rules on safety and civil law questions on liability' (EC 2018). So, horizontal and sectoral rules need to be reviewed to identify any rising risks as well as to protect and ensure benefits from the integration of AI enhanced technology at work. The Machinery Directive, the Radio Equipment Directive, the General Product Safety Directive and

other specific safety rules provide some guidance, but more will be needed for workplace safety and health. Indeed, a report in the IOSH Magazine emphasises that AI risks 'outpacing our safeguards' (Wustemann 2017) for workplace safety. In that light, this section looks at the perspectives of policymakers and experts from the wider community and emerging recommendations for dealing with AI, work and OSH in the context of future predictions.

4.1. European Commission

The Digital Single Market is important vehicle for the expansion of AI, and the Mid-Term Commission Review on the implementation of the Digital Single Market (European Commission 2017a) indicated that AI will provide substantive technological solutions to risky situations such as fewer fatalities on the roads, smarter uses of resources, less pesticides, more competitive manufacturing sector, better precision in surgery and assistance in dangerous situations like earthquake and nuclear disaster rescue. Debates across Europe involve questions about the legal and liability issues, data sharing and storage, risks of bias in machine learning's competences, and the difficulty in allowing for the right to an explanation including how data is used about workers, firmed up by the General Data Protection Regulation (GDPR) discussed below. So, the arena that is covered by the mid-term review of the Digital Single Market which has implications for AI, OSH and work, is the discussion of the risks of bias and the right to an explanation of data, where informed consent for the use of data and the right to access data held about the person is paramount. The socio-economic and ethical issues of AI have been further highlighted in more recent EC communications, particularly since the April 2018 Communication on Artificial Intelligence for Europe, which outlines the EC AI strategy.

4.2. International Standards

A committee within the International Standards Organisation (ISO) in 2018 and 2019 is currently working on designing a standard that will apply to uses of dashboards and metrics in workplaces. The standard will include regulations around how dashboards can be set up and on worker data gathering and use. Quantification tools are becoming increasingly of interest to employers, but the data is of no use if it is not standardisable. Representatives from the manufacturers of the software used to standardise data, SAP, are active in the ISO discussions, but it is important for further actors to participate in order to ensure co-determination in Germany, for example, and to ensure worker representation more broadly across the international landscape.[xii] International standards can be an effective way to ensure the benefits of these tools are achieved and one important step is to ensure that international corporate practices are equivalent at some level, that data is standardisable and that workers are involved in the discussions and implementation processes. Furthermore, risks assessments could be carried out on the basis of the extensive data gathered by these dashboards, which are a clear benefit for OSH protection.

[xii] Interview with Rolf Jaeger, European Industrial Relations Intercultural Communication and Negotiation.

4.3. World Economic Forum and GDPR

The World Economic Forum (WEF) Global Future Council on Human Rights reported in 2018 that, even when good data sets are used to set up algorithms for machine learning, there are considerable risks of discrimination if the following occur:

1. Choosing the wrong model.
2. Building a model with inadvertently discriminatory features.
3. Absence of human oversight and involvement.
4. Unpredictable and inscrutable systems.
5. Unchecked and unintentional discrimination. (WEF 2018)

The WEF emphasises that there is a distinct need for 'more active self-governance by private companies', which is in line with the United Nations' International Labour Organisation's Multinational Enterprises and Social Policy Declaration, Rev. 2017, which provides direct guidance for enterprises in the areas of sustainable, responsible and inclusive working practices and social policy surrounding this, where the Sustainable Development Goal (SDG) target 8.8 aims at achieving safe and secure working environments for all workers by 2030. The prevention of unfair and illegal discrimination clearly must be ensured as AI is increasingly introduced and the WEF and UN reports are vital for steering the course.

The first error a company can make in using AI which could lead to discrimination as listed by the WEF, is in a situation whereby a user applies the same algorithm to two problems, problems which may themselves not have identical contexts or data points. A possible workplace application of this problem could be where potential hires are considered using an algorithm that looks for clues about personality types via searches through social media, videos that detect facial movements, data that is collated across datasets of curriculum vitae, perhaps extending back a few years of hiring. The algorithm, then, as Dr Cathy O'Neil pointed out in an interview with the current author,[xiii] has to be designed to be discriminatory or at least selective, because hiring practices require that at a basic level. However, if for example, the algorithm is looking for extroverted people for a call centre job, the same algorithm would not be appropriate to find the right lab assistant, where talkativeness is not inherently in the job description. While the application of the algorithm would not necessarily lead to illegal discrimination as such, it is not difficult to extrapolate the possibilities for misallocation.

The second error, 'building a model with inadvertently discriminatory features', can refer to e.g. using a databank that already exemplifies discrimination. For example, in the United Kingdom, the gender pay gap has been exposed recently, where for years, women have been working at lower salaries and in some cases doing the same work as men, for less pay. If the data that demonstrates this trend were used to create an algorithm to make decisions about hiring, the machine would 'learn' that women should be paid less. This demonstrates the point that machines cannot make ethical judgements independently of human intervention.

The third error emphasises human intervention, which are now required across Europe. In May 2018, the GDPR became a requirement, where worker consent for

[xiii] Dr Cathy O'Neil, author of *Weapons of Maths Destruction* and CEO of ORCAA, interviewed with the current author 14/10/18.

data collection and usage applies. While the GDPR looks primarily at consumer data rights, there are significant applications for the workplace, where workplace decisions cannot be made using automated processes alone.

Section 4 of the GDPR document outlines the 'Right to object and automated individual decision-making'. Article 22, called 'Automated individual decision-making, including profiling', indicates that:

> 22(1): The data subject shall have the **right not to be subject to a decision based solely on automated processing**, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her.

The foundations for the Regulation, listed in the first sections of the document, make it clear that:

> (71): The data subject has the **right not to be subject to a decision**, which may include a measure, evaluating personal aspects relating to him or her which is based solely on automated processing and which produces legal effects concerning him or her or similarly significant affects him or her, such as… **e-recruiting practices without any human intervention**. Such processing includes profiling that consists of any form of automated processing of personal data evaluating the personal aspects of a natural person, in particular to analyse or predict aspects concerning the data subject's performance at work… reliability or behaviour, location or movements, where it produces legal effects concerning him or her or similarly significantly affects him or her.

Failure to apply these criteria could lead to unfair or illegal discriminatory decisions.

With regard to the fourth error, 'unpredictable and inscrutable systems', the description in the WEF document indicates that 'when a human makes a decision, such as whether or not to hire someone, we can *inquire* as to why he or she decided one way or the other' (italics added). Unfortunately, a machine cannot discuss rationale for decisions it reaches based on data mining. This is because the rationale is purely quantitative. The elimination of qualified judgements and lack of human intervention thus, creates a clear route to discrimination.

The final error in the implementation of AI can be when 'unchecked and intentional discrimination' occurs. This could happen for example when a company in fact does not want to hire, the report notes, women who are likely to become pregnant. While this position would not hold up in court, a machine learning system could provide covert tactics to make it happen, through an algorithm designed to out to filter out a subset of women candidates where that might be the case, based on age and relationship data. It is not difficult to see how this opens the door to not only the risks, but in fact the likelihood, of technically illegal discrimination.

5. Training for AI and OSH

How can workers be prepared for the integration of AI into workplaces? Training for OSH has at times been seen as an arena solely populated by the one or two health and safety officers in workplaces and not been fully integrated into all systems. One

IOSH expert indicated that training must be adjusted for relevance in the era of *Industrie 4.0* and digitalisation, so that workers are prepared to deal with rising risks. However, this is not a panacea and must be part of a larger implementation plan. If there is no plan to actually implement and utilise any new knowledge and skill delivered by training, new skills will be lost. In that light, better alignment between OSH training and integrated technologies is necessary. That being said, training pedagogy should also be adjusted, since learning is a process that will need to continue throughout workers' lifetimes particularly in the current climate of job uncertainty. It will also be important for workers to acquire problem solving skills and principles as well as traditionally understood 'skills'. These days, workers should understand and choose their own learning pathways and styles.[xiv] One IG Metall expert indicated that people must be trained to acquire fast learning capabilities, because technology changes quickly and skills thus must adapt.[xv] Only time will tell to what extent AI becomes ubiquitous in workplaces, but it is worth staying alert to the risks and possible benefits and in involving workers in these processes through providing training at every juncture.

6. In conclusion

Predictions even as far back such as the 1920s science fiction author E. M. Forster, painted a dystopian picture of technology and humanity. Forster's classic story *The Machine Stops* talks about a world where humans must live underneath the earth's surface, within a machinic apparatus that the protagonist of this novel celebrates, because the machine:

> …feeds us and clothes us and houses us; through it we speak to one another, through it we see one another, in it we have our being. The Machine is the friend of ideas and the enemy of superstition: the Machine is omnipotent, eternal; blessed is the Machine! (Forster 1928)

But the omnipotent, all-housing contraption soon begins to decay in this classic literary masterpiece, and human expertise is not sufficient for its maintenance, leading to a grim ending for all of humanity. While this is merely a classic piece of science fiction, today, technology's seeming invisibility, operations and potential power, are seemingly endlessly perpetuated because its operations are often hidden within a black box, where its workings are often considered beyond comprehension, but seem, still, to be accepted by the majority of people. Most people are not engineers, so do not understand how computers and AI systems work. Nonetheless, human experts are surprised with AI actions, such as the chess GO player who was beaten by a computer programme.

In China, the government will soon give each person a Citizen Score, or an economic and personal reputation scoring, that will look at people's rent payments, credit rankings, phone usage and so on, used to determine conditions for obtaining loans, jobs and travel visas. Perhaps people analytics could be used to give people Worker Scores used for decision-making in appraisals, which would introduce all sorts of questions about privacy and surveillance. The 'algorithmic condition'

[xiv] Duncan Spencer, Head of Advice and Practice, Institution of Occupational Safety and Health, based in Leicester, UK, talked about this with the author in an interview 15/10/18.
[xv] Interview with Dr Maike Pricelius, Project Secretary Arbeit +> Innovation IG Metall 12/10/18.

(Colman et al 2018) is a term also coined in one recent EU report, referring to the increasingly normalised logic of algorithms, where symbols are transformed into reality. This condition is beginning to impact many workplaces today, where online reputations are subject to algorithmic matching and people's profiles subject to data mining bots. The problem is that algorithms do not see the qualitative aspects of life, nor surrounding contexts. Dr O'Neil, also cited above, made an insightful observation in a recent interview with the current author. Whilst watching Deliveroo riders hurtle past her in the rain, Dr O'Neil considered the platforms directing riders in their work, which operate on the basis of efficiency and speed, and thus instigate riders to cycle through unsafe weather conditions. This clearly puts riders' very lives at risk. Dr O'Neil called algorithms 'toy models of the universe', where these seemingly all-knowing entities actually only know what we tell them, and thus have major blind spots.

Google co-founder Sergey Brin addressed investors in his annual founder's letter earlier in 2018 stating that:

> …the new spring in AI is the most significant development in computing in my lifetime… however, such powerful tools also bring with them new questions and responsibilities. How will they affect employment across different sectors? How can we understand what they are doing under the hood? What about measures of fairness? How might we manipulate them? Are they safe? (2018)

Ethical questions in AI must be discussed beyond the corporate sphere, however, and this report has covered these questions surrounding OSH and the risks as well as benefits that are introduced. The mythical invention of Forster's all-encompassing machine in his classical science fiction story was not, of course, subject to a range of ethical and moral review panels before all of humanity began to live within it, under the earth's crust. This dystopia is not what we face now, but current discussions from the European Commission to trade union curriculum review groups show significant interest in mitigating the worst risks of OSH as AI is increasingly implemented for workplace decision-making.

In conclusion, as the implementation of AI at work is relatively new, there is only nascent evidence of OSH risks and benefits. Nonetheless, this report has covered some of the arenas where benefits are being noted and supported and risks are highlighted, well as caution and regulation applied. In human resource decision-making with the use of AI augmented people analytics, the risk of unfair treatment and discrimination is already being reported. In automation and *Industrie 4.0*, risks involve unsuitable or unavailable training leading to overwork and stress, unpredicted accidents such as collisions between humans and robots, and deskilling of work with the integration of lot size manufacturing processes with the use of wearable technologies such as the HoloLens (note that deskilling is an issue in more than just the manufacturing context). Risks of privacy relating to intensified surveillance and feelings of micro-management have been reported as management are able to access more intimate data about workers because of wearable technologies in factories and offices alike.

To mitigate against OSH risks, it will be important to maintain focus on the positive possibilities of business application and ensure government oversight of AI in the

workplace. The positive effects of AI, when AI is implemented with appropriate processes, are that it can help management reduce human bias in interviewing processes, if attention is paid to algorithms and designed to identify evidence of past discrimination in decision-making and decisions are made with full human intervention and even affirmative action. AI can help to improve relationships with and between employees when data that is collected demonstrates potentials for collaboration. AI enhanced HR tools can improve decision-making via prediction by exception; and allow people more time for personal and career development, if AI can start to take over repetitive and unfulfilling work.

To avoid risks for OSH, the current author recommends focussing on implementing assistive and collaborative AI rather than heading for the general and widespread competences of UAI. Appropriate training must be provided at all points. Appropriate checks must also be made consistently, alongside OSH departments and authorities. Workers must be consulted at all points when new technologies are integrated into workplaces, sustaining a worker-centred approach and prioritising a 'human in command' approach (De Stefano 2018). Business owners and governments should keep an eye on international standardisation, government regulation and trade union activities, where significant progress is already being made to mitigate against the worst risks in AI and to develop positive and beneficial gains. In conclusion, it is not AI technology itself that creates risks for safety and health of workers, it is the way that it is implemented, and it is up to all of us to ensure a smooth transition to increased integration of AI in workplaces.

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