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Abstract

This paper is concerned with scholarly ergonomics and human factors (E/HF) contributions to date to the field of research inquiry known as the 'future of work'. The review considers E/HF perspectives on how the nature of work is changing and what this means for the practice of E/HF and for human performance and wellbeing at work. This field of research has attracted much attention from scholars from various disciplines as flexible working arrangements and casualised employment, in particular, have come under the microscope during the COVID-19 pandemic. The paper begins by setting out the future of work field, focusing on the mega trends and future of work forces that are most relevant to the discipline. Next, E/HF contributions to this field are identified and discussed. Surprisingly, given the E/HF tradition as a systems discipline fundamentally concerned with the study of human work, and as a contributor to transdisciplinary research related to the design of work systems, a search of the scholarly literature found few contributions outside of the automation systems field that addressed the future of work and E/HF directly. A research agenda is presented to address gaps in current knowledge in a number of key future of work domains.

Practitioners summary

We reflect on E/HF contributions to the 'future of work' field and how the practice of E/HF needs to consider the changing nature of work. We outline future of work concerns and suggest research areas for further E/HF attention towards the design of decent and sustainable work for all.

1. Introduction

The future of work has become a dominant concern for governments, industry and labour organisations globally. Indeed, the changing nature of work has received much attention during the COVID-19 pandemic, with renewed interest, for example, in the issue of how technology can support effective remote working and telehealth practice under social distancing restrictions, and the impacts of such arrangements on the wellbeing and performance of workers. Beyond the immediate concerns of COVID-19, the paper seeks to understand E/HF contributions to the future of work field at a macro-level. We first set out the future of work field, including the key forces that are changing the nature of work, before reviewing relevant E/HF contributions to research and practice, and considering potential areas for future E/HF research.

Human Factors and Ergonomics (E/HF) has been variously described as being a design discipline, a systems discipline, a people-centered discipline, a discipline concerned with the study of human work, and a discipline that has a focus on fitting the task to the person in the work system (Dul et al., 2012; Singleton, 1974; Wilson, 2014). Further, the goal of E/HF has been said to be to improve both human performance and wellbeing through effective integration of the physical, organisational and social environments or sub-systems – through

fitting the environment to the human (Dul et al., 2012). Given these underpinning discipline characteristics, one might expect E/HF research to have been a central contributor to the field of inquiry known as the future of work, if not right at the cutting edge of this growing field. This presumption is based on the notion that E/HF must be concerned not only with the traditional workplace and workspace, traditional work arrangements, traditional job design, traditional tools of work, and health, safety and performance associated with the world of work as we know it, but also with new forms of work and organisation, and the changing physical, organisational, social and political environments within which such work takes place.

Automation, robotics, and smart technologies are perhaps the most debated concerns when the future of work is considered, usually in relation to the impacts of such technological advancements and innovation on the nature of work and as a threat to current and future jobs. As one would expect, the design and evaluation of autonomous systems is an area where E/HF has been most prolific in its contribution, with much focus on automation across a number of areas of application, notably: autonomous vehicles, robotics and unmanned systems, human-robot interaction, trust in automation, and cognitive load and task complexity. However, these E/HF contributions have been largely focused on micro aspects of automation (with a small number of exceptions), and the design of automated and robotic systems rather than their impacts on work. For this reason, they have been excluded from the present review, which focuses instead on those broader future of work concerns that require a macro perspective. Similarly, as the office workplace has transitioned from the typewriter to mobile computing devices in the last three decades there have been many E/HF contributions to the change in work and its consequences

(Carlson, Schwartz, Greenwell and Casura, 2019). These have often been focused on equipment design and the prevention and management of musculoskeletal disorders. Greater technology utilisation has resulted in an increase in the sedentary nature of work and the health risks associated with it, such as diabetes and obesity (van Uffelen et al., 2010). These issues have also attracted E/HF attention, although there tends to be an emphasis on individual behaviour, for example, in the introduction of alternative workstations (Buckle et al., 2015; Schwartz, Kapellusch, Baca and Wessner, 2019) or workplace exercise programs (Commissaris et al. 2016). Investigating micro issues can lead to examination of a macro perspective, as is evidenced by the consensus of ergonomists over time that the management of workplace musculoskeletal disorder is most effectively managed with a multi-factorial approach (Devereux, Vlachonikolis, and Buckle, 2002; Widanarko, Legg, Devereux, and Stevenson, 2014). However, in this paper we focus on the the wider, macro design of the future of work and discuss the implications of technology in the context of in new ways of working in section 4.1.

Clearly, a discipline concerned with the study of human work must be responsive to those factors changing the nature of work, how and where we work, the organisation of work, the composition of the future workforce, and the interactions between these system elements in influencing potential performance, health, safety and wellbeing outcomes (Dul et al., 2012), yet we believe the discipline has yet to produce an adequate framework reflecting these changes to inform the profession and the practice of E/HF. Indeed, it is in these interactions between people, their work and society where our contributions should be found, drawing on E/HF science developed for the world of work as we have known it and applying it to the world of work that continues to change shape in the information age.

This, we contend, is a process best undertaken within the broad theoretical frame of the socio-technical systems approach. However, given the critical role of macro, global factors in shaping the new world of work, it is necessary to extend this view to include social, cultural and other extra-organisational influences on the future of work (see figure 1 in Moray, 2000).

This review paper begins by setting out the future of work field, focusing on the mega trends and future of work forces that are most relevant to the discipline of E/HF. It is not possible to examine each of these trends in detail within the context of such a broadly scoped review, although we have attempted to provide a greater degree of coverage where we feel the issue is especially pertinent to the E/HF discipline. Next, we overview existing E/HF contributions to the field, noting where there are gaps and laying out a research agenda that is necessary if as a discipline we are not to be left behind in an outmoded world of work. Within this conversation, we note that E/HF is a transdisciplinary science and its most important contributions will occur in collaboration with related research and practice from other fields. As always, like Bartlett, we advocate for early E/HF input to the design of work for the future.

2. Method – literature search

The review was concerned with the role of E/HF in understanding how future of work forces are impacting the nature of work and what this means for human performance and wellbeing, and E/HF research needs to address such concerns. A range of different search parameters were used to explore the literature in Scopus and Business Source Complete databases from which the final search terms were decided upon. These were: 'future of

work' or 'new ways of work*' in the title/abstract/keywords, and the terms 'ergonomics' or 'human factor*' or 'industrial engineering' or 'design' or' manufacturing' or 'safety' or 'management' in the source title. As noted above, the review excluded E/HF in the design and evaluation of automated systems and robotics. The initial search was conducted in June 2018 and was augmented by further methods due to the relative scarcity of E/HF literature on the issue. This included snowballing (checking the reference lists of papers identified in the search), handsearching E/HF journals and conference proceedings not indexed in the databases involved, contributions to the sample from personal contacts (active E/HF researchers in the field) and the inclusion of relevant grey literature on the future of work. The initial review was updated in late 2019 to capture any new contributions to the field prior to submission of the paper for review, and subsequently mid-2020 after first review

3. Findings and Discussion

3.1 The future of work – mega trends and forces changing the nature of work

Karl Marx famously predicted that capitalism would bring about a progressive de-skilling of labour, while others, notably John Maynard Keynes, predicted that shorter working hours would result. Indeed, there has always been a fascination amongst our greatest thinkers and social commentators as to what work in the future will look like. Many have been proven at least partially incorrect as technology advances that could not have been imagined by the likes of Marx have revolutionized the workplace and threaten to change the very nature of work as we have known it – not just in what we do, the job content, but in the social organisation of work, where work happens, and how we think about work as an activity (Gratton and Scott, 2016).

As early as 1962, Fredrick Bartlett predicted that technological innovation would continue to change existing work activities into new work activities. Indeed, the future of work has been conceptualized largely in relation to technological innovation, and in particular the automation of jobs. Much of the commentary in the media and amongst scholars has been around automation, and more comprehensively, 'Smart Technology, Artificial Intelligence, Robotics and Algorithms' (STARA), and the threat posed to jobs (Brougham and Haar, 2017). Here, it is argued that many of the jobs and tasks that humans presently perform, both physical and cognitive, will be performed in the near future by machines (Frey and Osbourne, 2013; Robertson and Cooper, 2018), or through the collaboration between people and machines. However, while fears around technology as a threat to jobs are a central theme of the literature and social commentaries in the future of work field, others have argued that we should be as much concerned about the further erosion of the quality of work as a result of technology, as for the loss of jobs and work per se (Hancock 2017).

However, the impact on work of technological advancements is not limited to concerns around automation. Indeed, the focus of the broader research literature in this field is on the more general application of new technologies and how they are changing the way we work, where we work, and how much work we do (Cooper, 1998). This research tends to focus on the wellbeing issues arising from an 'always on' culture and the growth of flexibility and particularly distributed working, the gig economy and casualisation (Bentley et al., 2016; Robertson and Cooper, 2018; De Stefano, 2016).

A number of governmental studies internationally have attempted to forecast the future of work, with most having a strong focus on the impacts of technology and change on the

labour market, jobs and future skills needs. The UKCES report (2014), 'The Future of Work: Jobs and Skills in 2030, is an excellent example. Rhisiart, Störmer and Daheim (2017) point out that this study, which was part of the UK government's Foresight programme, has been the most downloaded of all UKCES reports, evidencing the strong interest and appeal of the study and its focus.

Internationally, interest in the future of work has been strong amongst those bodies concerned with worker health and social justice, including the World Health Organisation (WHO) and the International Labour Organisation (ILO). In 2015, the ILO identified the future of work as the centrepiece for its Centenary (ILO, 2015). The ILO's Future of Work Centenary Initiative report noted the need to understand and respond to processes of change that were rapidly transforming the world of work. The scope of the ILO review of such changes covered four interrelated themes: work and society, decent jobs for all, the organisation of work and production, and the governance of work. Specific concerns for the ILO agenda for social justice within this scope included: the work experience of individuals; the changing nature of work, including flexibility and special and functional mobility; decent work and jobs and how realistic such goals are when the 'global jobs machine is broken' and unemployment and underemployment continue to grow; technological advancements and their disruptive impacts on jobs, including the labour-replacing potential of technology and the changing need for skills and training; non-standard employment and ongoing threat to the employment relationship, and the rise of flexible working practices, including remote working and the opportunities and problems associated with new ways of working.

In 2019, the ILO set out the The ILO Centenary Declaration for the Future of Work. This Declaration called for a people-centred approach and a call for action to member states to ensure people benefited from changes in the nature of work, that the employment relationship remained relevant, protections for all workers, and the promotion of sustainable and decent work (ILO, 2019). Further to this, the ILO (2019) Global Commission on the Future of Work published 'Work for a Brighter Future'. This proposed a 'human-centred agenda' with three pillars of action aimed to drive growth, equity and sustainability: increasing investment in people's capabilities, institutions of work, and decent and sustainable work. This publication prompted a proposal for collaboration between the International Ergonomics Society (IEA) and the ILO (Mosier & Hiba, 2019) to ensure attention is given to the HFE perspective to design and implement work systems for the 'future of work we want'.

While much of the focus of these and other initiatives has been around how technology has impacted work, the future of work is much broader than technology (as the ILO, 2015 paper attests), and as Rhisiart et al. (2017) note, a wider socio-economic and systemic perspective is needed in this field. The changing nature of work has also been a major focus for industrial relations researchers and others interested in labour markets and standards, from which initiatives such as ILO's Decent Work Agenda and the European Pillar of Social Rights have emerged (see Cappelli, 1995; Burchell, Sehnbruch, Piasna and Agloni, 2014). Looking beyond the central role of technology and labour standards, the scope of the future of work field is generally acknowledged to include a wider range of concerns, often conceptualised in terms of mega trends and future of work forces. A good summary of these trends as they relate to safety and wellbeing can be found in a recent white paper on the risks associated

with future work, published by the British Safety Council authored by Mike Robertson and Sir Cary Cooper (2018). This paper echoes the concerns outlined by the ILO, but the focus is more specifically around health, safety and wellbeing risks arising from changes in the nature of work and society. The authors characterise the future landscape of work as incorporating: technological advances, including AI and automation, co-bots and collaboration and ICT developments changing the nature of work; labour market demand, including the gig economy, insecure work and skill requirements; labour market supply, including skills shortages and demographic changes; and environmental change, including climate change and resource scarcity. This commentary on changes to the working landscape is typical of other such contributions to the literature.

Figure 1 summarises the major future of work forces and mega trends as commonly set out in the scholarly and grey literature on the topic. A selection of sub-themes commonly associated with each of the forces and trends are also shown. It is important to note that these are not mutually exclusive categories and many interact and relate to others, usually through the medium of technology. For example, advanced digital technology gives rise to not only automation and innovations in production and service systems, but new organisational forms and new ways of working. Through these interactions, the nature of work and critical concerns to the E/HF discipline such as worker health, safety, wellbeing and performance, and the quality of work experienced by workers, are impacted.

Having broadly set out the scope of the future of work field, drawing particularly on scholarly research published outside the discipline's journals, we now turn our attention to E/HF contributions to the future of work.

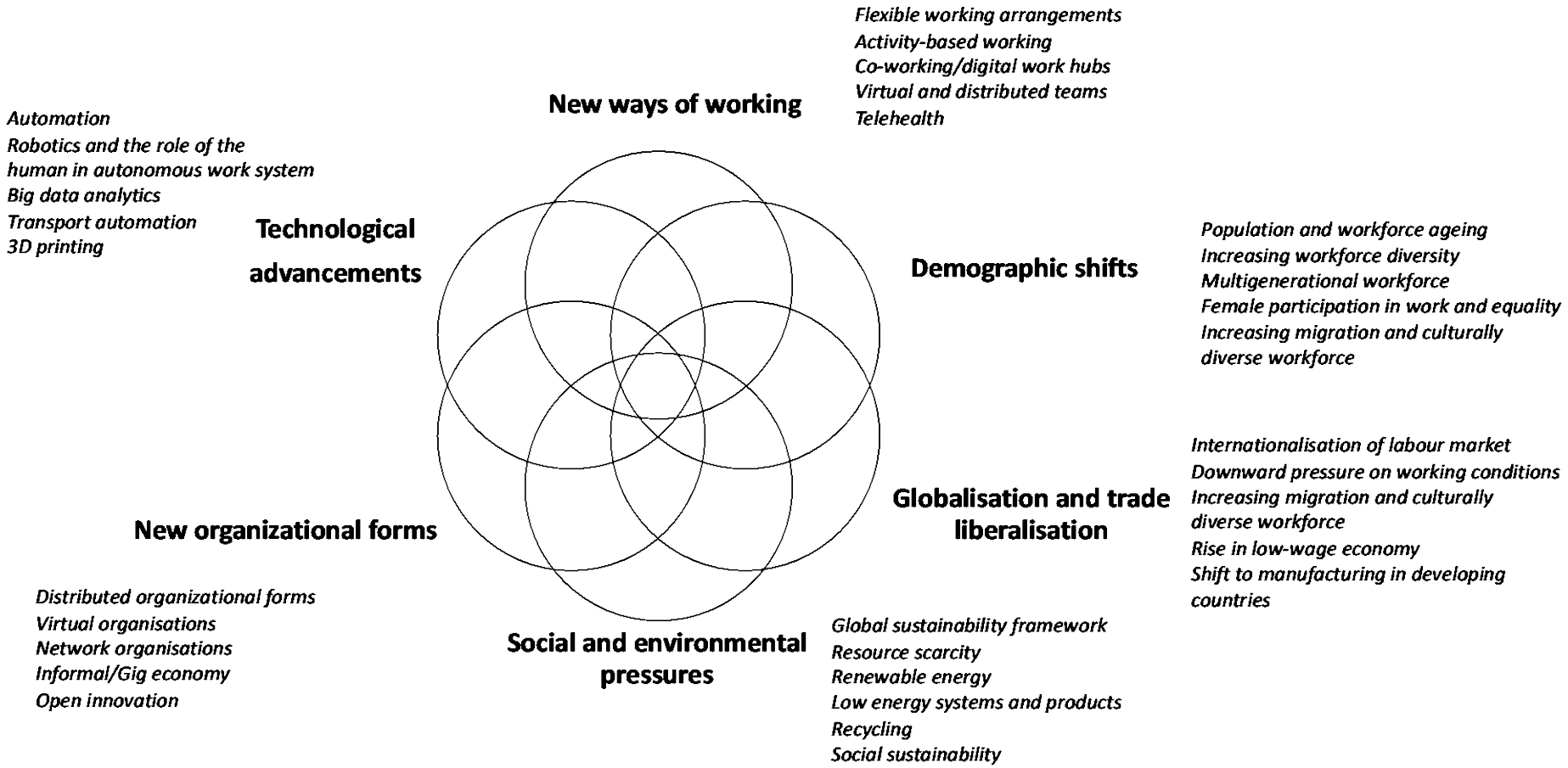

Figure 1. Future of work forces and mega trends

3.2 Summarising human factors and ergonomics contributions to the future of work field

A search of the two article databases using the key term 'future of work', undertaken in June 2018 produced some 296 hits. The first contribution to the field being a 1956 paper in the Lancet (no author name available). Publication in the field peaked in 2017 (thus far), with some 34 outputs on the topic. By far the greatest contributors to the future of work field from a discipline perspective were the social sciences and business, management and accounting. Areas related more closely to ergonomics had lower hit rates, including computer science, engineering, and psychology. Just a handful of E/HF contributions were found.

Table 1 summarises the E/HF contributions that consider the role and contribution of E/HF to future of work problems, taking a macro view as opposed to focused research and practice related to a single problem. As E/HF contributions are relatively scant, the review has also included a selection of papers and contributions from the grey literature that the authors felt were fundamentally relevant to the discipline.

Table 1. E/HF and related contributions to the future of work field

Paper no.	**Authors of E/HF contributions**	**Title**	**Summary**
1	Bartlett, 1962	The future for ergonomics	Issues that set the agenda for future ergonomics research
2	Moray, 1995 *Ergonomics*	Ergonomics and the global problems of the twenty-first century	Considers the major ecological and social challenges of the coming century, and the role of ergonomics in changing human behaviour and other issues related to future sustainability
3	Hancock, 1997 *Ergonomics in Design*	On the future of work	On understanding changes to the nature of work in the future that will influence the role of ergonomics in design
4	Drury, 2000 14th IEA conference proceedings	Quality, globalisation and the future of work	Globalisation, new forms of organisation and working. Impacts of globalisation on quality

5	Drury, 2008 *Ergonomics*	The future of ergonomics/the future of work: 45 years after Bartlett (1962)	Looks at how Barlett's 1962 predictions stand up, and implications for ergonomics
6	Hancock, 2008 *Ergonomics*	Fredrick Bartlett: through the lens of prediction	Looks at how Barlett's 1962 predictions stand up, and implications for ergonomics
7	Caple, 2008 *Ergonomics*	Emerging challenges to the ergonomics domain	Reflecting on Bartlett's predictions, largely around MSD risk in today's workplace . Calls for an extension of macro-ergonomics.
8	Stanton and Stammers, 2008 *Ergonomics*	Bartlett and the future of ergonomics	Editorial review of Bartlett and other future of ergonomics commentators
9	Waterson and Eason, 2009	1966 and all that: Trends and developments in UK ergonomics during the 1960s	Mainly focused on trends and developments emerging out of the 1960s in comparison with practice at the time of publishing. Considers the role of a number of emerging areas of interest, including automation
10	Dul et al, 2012 *Ergonomic*s	A strategy for human factors/ergonomics: developing the discipline and profession	Characteristics of ergonomics discipline, global changes and strategy for the future
11	Thatcher, Waterson, Todd and Moray, 2018 *Ergonomics*	State of Science: Ergonomics and global issues	Review of what has been accomplished by the E/HE discipline in response to the challenges raised in Moray's 1993 keynote to the Congress of the International Ergonomics Association. Includes a set of predictions for the future and priorities for addressing sustainability challenges related to E/HF
12	Mosier and Hiba, 2019	The essential contribution of human factors/ergonomics to the future of the work we want	Commentary by IEA President and Chair of IEA task force on the future of work to propose a collaborative effort between ILO and IEA.
	General literature		
13	Cooper, 2005 *Career Development International*	The future of work: Careers, stress and wellbeing	On the future of work as it relates to careers, particularly in relation to flexibility
14	International Labour Organisation (ILO), 2015	The future of work centenary initiative (Report of the Director-General)	The ILO report reviewed changes associated with the future of work that impact their agenda and social justice in particular. The review covered four interrelated themes: work and society, decent jobs for all, the organisation of work and production, and the governance of work.
15	International Labour Organisation (ILO), 2019	The ILO Centenary Declaration for the Future of Work	Sets out the The Future of Work Centenary Declaration which was adopted in 2019 at the 108th Session of the International Labour Conference.
16	International Labour Organisation (ILO), 2019	Work for a brighter future-Global Commission on the Future of Work	Portrays the urgency of changes to the world of work and presents ideas on how to manage the changes. Proposes a human-centred agenda for the future of work.
17	Harrison and Dawson, 2016	Occupational health: Meeting the challenges of the next 20 years	Literature review considering implications of society and workplace changes, including new

	Safety and Health at Work		ways of working, on future occupational healthcare provision
18	Robertson and Cooper, 2018 British Safety Council report	Future risk: impact of work on health, safety and wellbeing. A literature review.	Sets out health, safety and wellbeing concerns and risks arising from changes in the nature of work and society

In summary, just a handful of papers deal with E/HF and the future of work in a broad sense, with most being over twenty-years old. These contributions include Bartlett's (1962) seminal paper on the topic, and a number of brief papers and an editorial from Stanton and Stammers (2008) from a special issue of Ergonomics reflecting on the future of ergonomics 45-years after Bartlett. The following section provides a brief summary of the content of these key E/HF contribution to the future of work field, along with some notably articles within E/HF journals on specific future of work themes.

3.3. Commentaries and research on the future of work in the ergonomics and human factors field

In 1962, Sir Fredrick C Bartlett's Ergonomics Research Society Lecture in Loughborough considered the 'future for ergonomics' – a paper in which Bartlett made various predictions about the changing nature of work and the role of ergonomics in the future. In discussing the predicted technological changes that will reshape the future, Bartlett stressed the importance for ergonomists to keep pace with innovative developments and to ensure early input of ergonomics into design of these – now a well-established human-centred design principle (Hancock, 2008). The technological changes predicted by Bartlett and their impact on the nature of work have proven to be largely accurate (Caple, 2008; Drury, 2008; Hancock, 2008). Advances in digital technology predicted by Bartlett included automation changing the work people do, and changes in the skills workers employ, becoming

increasingly cognitive rather than physical. Drury (2008), in consideration of Bartlett's predictions, noted that while these are largely true, and lead ergonomics to be concerned with the interactions between people and intelligent systems, the ergonomics concerns around physical work have not gone away (even if they have to some extent been exported to developing countries). Indeed, Drury points out that musculoskeletal problems associated with repetitive work remain a major cost to industry globally, a fact that is just as true today in 2020 as it was ten years ago! In agreement, Caple (2008) pointed to the rapid increase in computer work that has led to a greater prevalence of neck and upper limb disorders and other physical and psychosocial problems associated with increased computer use.

Drury (2008) also argued that Bartlett's prediction that social isolation and sensory deprivation would increase as a result of technological advances was yet to come true. Drury did note, however, that social isolation was likely to be an outcome of non in-person forms of communication such as telecommuting. In fact, there has been some focus in recent years on wellbeing concerns associated with social isolation in distributed forms of work, and in particular virtual teams and telework/telecommuting, albeit with little apparent input from the ergonomics community (Bentley et al., 2016; Wohlers and Hertel, 2017).

Bartlett's prediction that there will be a 'period of intensive turnover from many existing work activities to new ones' has proved accurate and continues to escalate as technological innovation advances apace. Drury (2008) describes how technological changes coupled with globalisation have brought about changes to the nature of work, notably longer work

hours and work intensification, and increases in part-time work. The challenge for ergonomics within this changing world of work, he notes, remains the need to balance performance and wellbeing. Furthermore, Bartlett rightly predicted that mental workload would increase as a result of technological and job changes, as noted by Hancock (2008), although the vigilance aspect of mental load has failed to escalate as predicted.

While Bartlett did not go as far as to predict the radical changes to the employment environment around casualisation and the growth of non-standard, insecure work and the gig economy, he did rightly predict the rise in multiple job holding, noting that operatives will be combining two or more jobs which have generally been regarded as different – although, as Drury (2008) notes, these different jobs are typically with different employers rather than combined characteristics of a single job as foreseen by Bartlett.

An early commentary by Hancock (1997) was, perhaps, the first to consider changes to the nature of work that will influence the role of ergonomics in design and implications for the profession and practice of E/HF. Drury (2005) outlined some of the more important trends that have implications for the discipline. These include societal influences such as organisational decentralisation, demographic changes - notably through immigration, workforce ageing, increases in female participation in work, technological advances and changes to work - including the move to service, technology in the workplace, globalisation and working times. Yet, there is little evidence of the discipline responding to such calls, nor did other published work on the subject appear in our journals until 2008.

Returning to these themes as part of a special issue of Ergonomics 45 years after Bartlett, Drury (2008) attempted to predict the future of the ergonomics discipline, at least in terms of those changes that E/HF must be concerned with. Within this brief commentary, Drury discussed these changes as related to 'changes in the world' and 'changes in the enterprise'. Changes in the world, in addition to advancing technology, were noted as changes in population demographics, changes in social interaction and increasing concern for sustainability. Importantly, Drury noted that the populations of Western countries are ageing while workforces have increasing numbers of older workers, and of course this has become a major trend impacting economies and the workplace (Bentley et al., 2017) and remains a central challenge for E/HF in terms of the design of work and work systems. Furthermore, Drury points to the increasing ethnic diversity, growing numbers of women and more people with disabilities within the workforce – all with system design implications.

Drury concludes his paper by predicting that jobs and workers are increasing in their variety and that workers will be expected to expand their job skills. Certainly, this is proving to be the case, with much emphasis in future of work discourses and in the education sector on the need for workers to continually update and expand their skills in order to be agile in the changing world of work, and to expect multiple careers rather than working within a single sector as was usual in the past. Furthermore, Drury (2008) argued that the intensity of work was increasing as was the variety of working times and the nature of work.

Chronologically, the next noteworthy contribution to the future of work and E/HF came from a highly cited paper by Dul and a number of senior colleagues (Dul et al., 2012). Within a paper broadly concerned with setting out a strategy for developing the E/HF discipline, the

authors outlined a number of developments in the 'external world' that are having major impacts on systems and E/HF. This work is probably the best example in the past decade of any attempt to determine the role for E/HF in the light of global changes and future of work forces that are re-shaping work. The developments outlined by the authors included global change to work systems, including the widespread outsourcing of mass goods manufacturing to developing countries, creating complex supply chains, and a shift within developed countries to service economies. These changes have resulted in changes in E/HF design work towards service work systems and non-work systems, amongst other new directions for the discipline. The authors also highlighted the growth in the informal and low wage sectors in many countries, and a continuing trend of automation that has changed the relationship between people and technology. A further focus of this review concerned demographic shifts and, in particular, workforce ageing and the need for E/HF to ensure work systems and products and services are fit for the older population, accounting for the changing capabilities, limitations and aspirations of older people. Furthermore, advances in information and communication technology have brought about changes in how work is organised, including the rise of remote working and network organisations. Dul and colleagues (2012) also noted that E/HF can contribute to the design of collaboration systems to support these new ways of working and the communication and information sharing between individuals, teams and organisations, as well as in the design of virtual social-technical systems.

Aside from contributions in the automation and robotics field, there appears to have been relatively little response from the discipline in terms of research addressing the concerns set out by Dul et al. (2012). One area that has begun to receive attention by E/HF researchers

and practitioners, however, is that of population ageing and the ageing workforce. A number of contributions to the literature on older workers, in particular, have provided an E/HF perspective on the 'workability' of older workers (usually defined as 55 years of age and above) and the design of work and organisational actions needed to support the continued participation in work of older workers. These contributions include those of Costa and Sartori (2007), who examined work ability amongst older Italian workers and intervention to maintain work ability. More recently, Bentley et al. (2017; 2019) explored the effectiveness of human resource practices in maintaining older workers in employment. The authors also examined the role of organisational, job and personal factors in older worker attitudes towards remaining in paid employment. These and other contributions have provided an initial view of E/HF factors that are important when considering extended working life and the performance and wellbeing of the ageing workforce, and suggest an important role for E/HF in supporting organisations in the effective management of older worker wellbeing, performance and retention – especially in those countries most impacted by workforce ageing, such as Japan (see Kumashiro, 2014) and New Zealand (Bentley et al., 2019).

A key theme highlighted by Dul and colleagues (2012) and evident within several of the commentaries reported above relates to the nature of work and how this has been disrupted and is predicted to continue to change into the future. Two aspects of particular interest to E/HF scholars have been the growth in sedentary work as a consequence of technological change and the growth in sectors characterised by sedentary roles, and the rise of new ways of working. While E/HF contributions have not set out to contribute to the

future of work debate specifically around these issues, there have been some useful contributions reported within the literature.

3.4 New ways of working and E/HF

New ways of working, including flexibility in time and location of work, are a relatively recent phenomena, enabled by advanced information and communications technology (ICT) (Gerards, de Grip and Baudewijns, 2018). These changes have many apparent benefits, including potential productivity increases, enhanced wellbeing, providing better balance between work and non-work time, giving greater opportunity for women and those with care responsibilities to engage in paid work, enhancing autonomy and satisfaction with work, reduced time spent commuting, organisational resilience (e.g. Green, Tappin and Bentley, 2017) and the environmental and social benefits of reducing fossil fuel omissions and inner-city congestion. However, flexible working also brings potential challenges, including an increased likelihood of social isolation and work family conflict where such arrangements are not well scheduled and managed (see Bentley et al., 2016). Indeed, remote working in particular has been associated with concerns around the blurring of spatial and temporal boundaries between work and non-work (ILO, 2015). These concerns have, of course, come under increasing public attention during the COVID-19 pandemic, and the need for many of the world's knowledge workers to work from home due to social distancing requirements.

Alongside working remotely/teleworking (Bentley et al., 2016), activity-based working and flexible office arrangements have become increasingly popular for knowledge workers. These arrangements provide different work locations to fit best with different work

activities (Robertson and Vink, 2012; Wohlers and Hertel, 2017), including open-office environments comprising collaborative spaces, plug-in-and-play areas, and other configurations that involve the design or redesign of office structures from cellular to non-cellular work environments and a move away from dedicated workspaces and offices. Research literature of the benefits and challenges of new ways of working is mixed, although there is plenty of appetite for the proliferation of such practices amongst organisations globally – not least in the post-COVID-19 era where organisations and workers alike may elect to maintain work from home arrangements for various reasons. E/HF researchers have begun to shine a light on specific aspects of new ways of working, including new ways of office work (Robertson and Vink, 2012), activity-based working/flexible offices (Wohlers and Hertel, 2017; Chafi and Rolfö, 2019), telework (Bentley et al., 2016), and working in alternative locations and non-traditional workspaces such as trains (Groenesteijn et al., 2014). At present, there is a real opportunity for E/HF in relation to how flexible working arrangements can best be designed in terms of the organisation of work, workplace and workspace design including the virtual environment, communication and policy design, support, training and equipment design, and the management of health, safety and wellbeing including increasing physical activity at work (Arundell et al, 2018). For example, Laughton and Thatcher (2019) found that different types of workplace layout involving agile workspaces impacted worker comfort, health and satisfaction with work in different ways, while Morrison and Smollan (2020) found that there was a gender difference in perceptions of being observed in an open plan office environment.

As with the other future of work trends discussed in this paper, new ways of working is best considered from a socio-technical systems perspective, although as noted earlier, it is necessary to extend this view to include social, cultural and other extra-organisational influences on the existence and design of work (Bentley et al., 2016). Further, from an E/HF view, new ways of working present new challenges from the traditional focus on the knowledge worker's workplace as a fixed location towards thinking about work as able to be done anywhere and anytime. Work, under these arrangements, is no longer thought of as a place to go, but as an activity (a verb, not a noun).

Clearly, the problems of work need to be considered from the perspective of multiple potential workplaces and workspaces, with the challenges that this may place on the design and management of work, and without the ability to readily monitor and assess risks faced by people working remotely. These issues present fundamental new problems for E/HF, such as to how to remotely assess remote activities carried out by workers and how to examine relationships between organisations who offer an activity and workers located in different world regions? While digital solutions to these problems are often available, including videoconferencing/telepresence and digital monitoring, these also raise issues around surveillance and privacy concerns.

3.5 Sustainability and E/HF

Sustainability can be defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Pfeffer, 2010). Sustainability and environment pressures are major future of work concerns and have been the subject of contributions from a number of scholars in the field. Dul et al.

(2012), for example, note that E/HF has the potential to contribute to the design of more sustainable systems, and that by optimizing both wellbeing and performance, E/HF contribute to corporate social responsibility goals that combine both people and profit dimensions of sustainability. Thatcher and Yeow (2016), in a contribution focused around human factors and sustainability, set out clearly why it is that E/HF has an important role to play in creating a sustainable future. They note that sustainability problems are human-created and, therefore, can be resolved through human effort, with E/HF contributing to 'the design and implementation of sustainable systems that support appropriate behaviour and ensure sustainability.' Moray's (1995) contribution has been to encourage E/HF to widen its lens to those global issues and to take a more macro and multidisciplinary perspective when considering E/HF problems. The role of ergonomics in changing human behaviour was, according to Moray, the way the discipline could best contribute to addressing the major ecological and social challenges of the coming century. Furthermore, ethical values needed to be considered in E/HF design contributions. Nearly twenty-five years on, Thatcher and colleagues presented a review of how E/HF has responded to those global challenges Moray raised in his 1993 keynote address to the Congress of the International Ergonomics Association (Thatcher, Waterson, Todd & Moray, 2018), concluding the response had been 'weak and disorganised'. The major contribution of this paper, however, was to set out a vision for E/HF and sustainability for the 21st Century, extending the work of Moray. This agenda noted the need for a greater emphasis on the system and complexity in E/HF compared to the strong micro-ergonomics approach that has dominated the discipline. Further, values and ethics should become a central concern for E/HF, while shifting the focus from general to local solutions to E/HF problems.

We end this brief discussion on E/HF contributions on the future of work and sustainability and global issues by noting that this has been a missed opportunity for the discipline, first highlighted by Haslam and Waterson (2013) and Martin et al. (2013), specifically in the context of ergonomics and sustainability. This is probably due to an overwhelming micro-level focus and a failure to establish E/HF as a key contributing discipline within the multidisciplinary effort that is required to address wicked problems with the complexity of sustainable development (Thatcher, Nayak, and Waterson, 2020). Furthermore, much of the focus of research in the sustainability literature more generally has been around environmental or green issues (see Hanson, 2013 on "Green ergonomics: challenges and opportunities", and Lange-Morales, Thatcher and García-Acosta, 2014, on 'ergoecology' and green ergonomics), whereas the role of people and human factors contributing to adverse impacts on sustainability, as well as the sustainability of people in the work system, has been received relatively little attention. This is the opportunity that must be grasped, as Martin et al. (2013) have argued, given the person-centered focus of E/HF and the importance of all facets of sustainability to our continued existence. Indeed, it is human activity that has led to the ecological consequences that threaten the very future of the planet.

4. A research agenda – key areas for E/HF research attention

Having reviewed the current state of science in relation to E/HF and the future of work, we conclude by suggesting areas for potential contributions for each of the six future of work forces or mega trends. Given the COVID-19 crisis and its dramatic impact on work itself and the social organisation of work, current at the time of writing this paper, some areas are likely to receive significant government and funder attention over coming years, presenting

opportunities for E/HF to play an important role in the design of future organisations, jobs, work systems and workplaces that are sustainable and supportive of effective wellbeing and performance. Table 2 offers a non-exhaustive list of areas requiring E/HF input, drawing from both the E/HF and general literature in the field. We note again that any such endeavor is most likely to occur within a multidisciplinary setting, involving E/HF collaboration with industrial designers and engineers, environmental scientists, organisational scholars, industrial and organisational psychologists, industrial relations scholars and other specialists involved in the design of work and organisations. Further, a sociotechnical systems approach is suggested as the most suited framework within which to locate the contribution of E/HF to the design of future work, extended to account for wider societal, technological, environmental, and cultural influences. The future of work is much broader than any single work system component such as technology (as the ILO, 2015 and 2019 papers attest, for example). As Rhisiart et al. (2017) note, a wider socio-economic and systemic perspective is needed in this field. Indeed, it is only by understanding these interacting work system elements and contextual influences external to the work system that E/HF can meaningfully contribute to the goal of systems design that effectively fits the task to the *future* worker and contributes to a future where jobs are sustainable, decent and safe.

Table 2. Future of work concerns and areas for future E/HF research attention

Future of work force or mega trend	**Potential areas for future E/HF contributions**
Technology advances	*This aspect is the one area well-served by E/HF and research and practice contributions are expected to continue in these and other potential areas for future E/HF:* • Allocation of functions

	• Changing relationship between people and technology (see Hancock, 2017) • Person-robot interaction • The role of the human in automated systems • Work systems design • Systems integration • Industrial design • Design of collaboration systems and virtual systems • E/HF use of human data from big data analytics (see Drury, 2015) • Autonomous vehicles • Drone applications • Internet of Things technologies • Design of telehealth systems
Globalisation and trade liberalisation	• Input into the design of global supply-chains and their regulation, based on principles of the Decent Work Agenda • Policy development for labour standards and protections, with a focus on including social dialogue and participation • E/HF for manufacturing systems in the developing world • Design of service production systems • OHS and wellbeing issues in non-standard and precarious work
Demographic shifts	• Cross-cultural design of production systems • Design of work systems for a diverse and distributed workforce • Cross-cultural design of equipment to fit user diversity • Work system and job design for older workers • Product and service design for older populations • OHS and wellbeing • Sustainable workforce issues across global supply chains
New organisational forms	• Collaboration and information sharing systems design for virtual organisations and network organisations • Virtual socio-technical systems • Education and skill requirements and capabilities for future work • E/HF problems associated with casualisation and informal sector • E/HF problems associated with gig and platform economies and the commodification of work • E/HF problems associated with multiple job holding • Design for flexibility and innovation for products and services
New ways of working	• Design of home working/remote working environments (hubs, vehicles, transport systems, etc.) • Design of activity-based working environments • Design of digital work hub environments • Design of social network and collaborative tools • Design of collaboration systems and virtual systems • OHS, wellbeing and physical comfort for virtual workers and for activity-based working • Telehealth systems design
Environmental pressures	• Green ergonomics (see Hanson, 2014) • Supply chain ergonomics

	• Sustainable design and socio-technical systems • Optimizing performance and wellbeing towards sustainability/CSR goals • E/HF applications to positively affect human behaviour • Vehicle design • Design for organisational and system resilience

5. Conclusion

Barlett's 1962 prediction that there would be a 'period of intensive turnover from many existing work activities to new ones' has proven true, but Bartlett himself would have been staggered to witness the extent of such disruption and change. Technological innovation has driven the creation of new jobs, roles and tasks within work systems, often as a component of an autonomous work system, and has resulted in an array of new organisational forms and ways of working. These changes have coincided and collided with massive demographic shifts, globalisation and an unprecedented rise in the internationalisation of work systems, and huge environmental pressures. Efforts to support business continuity and the maintenance of production and services during the COVID-19 pandemic have benefited from many such innovations, but the disruptions to working life and their consequences during this period have also highlighted limitations with flexible work systems and the way work is currently designed and organised. But, beyond COVID-19, what effect are these rapid changes having, and what impact will they continue to have, on the nature and experience of work, and how can the quality of jobs be protected in the face of such disruption? It is in addressing these questions that the E/HF discipline has its greatest opportunity and responsibility. Implicit in each of the potential contributions noted in Table 2, is the need for E/HF leadership in the design of good quality jobs (Jones, Haslam and Haslam, 2017). As a discipline, we strive to improve both human performance and wellbeing through effective system integration and fitting the task and environment to the

human (Dul et al., 2012). However, E/HF contributions must go beyond concerns for workplace health, safety, wellbeing and performance, to consider the role we can play in designing future work and work systems that promote psychological healthy, satisfying and fulfilling work (Jones et al., 2017). In short, workers should expect to be employed in decent work. In this respect, the ILO point to the Declaration of Philadelphia, noting workers should "have the satisfaction of giving the fullest measure of their skill and attainments and make their greatest contribution to the common wellbeing" (ILO, 2015). Further, the intent of Sustainable Development Goal 8, 'Decent work and economic growth', is to achieve full and productive employment, and decent work, for all women and men by 2030. Given the many future of work forces and trends mentioned in this review that might be expected have a negative impact on worker wellbeing and performance and the experience of decent work, especially in the informal sector, the challenge for E/HF is a daunting one, and can only be achieved through a multidisciplinary approach that has lifting the quality and sustainability of work and jobs at its heart.

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