Chapter 6
Organisational Challenges of Human–Robot Interaction Systems in Industry: Human Resources Implications

António B. Moniz

Abstract In this paper, the social aspects related to new concepts on the complex work environments (CWE) will be analysed, especially those that configure the design of work organisation systems with automated equipment. In such environments, the work with autonomous systems (AS) represents specific options in the design of workplaces. This means that human resources management (HRM) is becoming more decisive for a successful design of a complex and automated system. Traditionally, it was thought that automation would replace operational work and the importance of the dimension of human resource would become less decisive for management option. Most recent studies are demonstrating total different conclusions. We intend to present here some of those results. Another topic covered by this article is the relation of humans with computers in their working environment. That means the role of agents in the human–computer interaction (HCI) (robots, human operators, other automated machinery, sensors) and the implications in the management of human resources. The technology development represents also a challenge for managerial options.

6.1 Introduction

In an interesting article published in 1996, Masakasu Ejiri approached the future development of robotics. And already there he verified that "many robotics researchers believe that autonomous robots will play an important role in our future society" (p. 3 [1]). This researcher from Hitachi Lab understood that most problems could be more visible on the possibilities for mobility and motion

A. B. Moniz (✉)
Universidade Nova de Lisboa, Campus da FCT, Caparica, Portugal
e-mail: abm@fct.unl.pt; antonio.moniz@kit.edu

A. B. Moniz
Karlsruhe Institute of Technology, ITAS, Karlstr.11, Karlsruhe, Germany

C. Machado and J. P. Davim (eds.), *Human Resource Management and Technological Challenges*, Management and Industrial Engineering, DOI: 10.1007/978-3-319-02618-3_6,

control, or on energy and battery developments. But a lack of research was done on "machine reliability". He concluded on the state of the art of that time that "we should direct efforts towards providing assistance to human drivers" [1]. He foresees the development of robotics into this direction when he provides the example of medical field applications: "we have to note that the final goal should not be an automatic surgery machine, but a machine with the capability to help a surgeon as a skilled assistant" (p. 4 [1]). This is one of the main discussions in this paper about what would mean the role of agents in the human–computer interaction (HCI) (robots, human operators, other automated machinery, sensors) and the implications in the management of human resources.

6.2 Organisational Challenges

The role of the different agents in the interaction between humans and information technologies also means the discussion about the technological developments in each of the elements that participate in the working environment. Means also their implications in the way humans work and use such agents or elements of their work environment. This includes the definition of decision process in complex working systems (CWS). That contributes to consider what an autonomous system in the production sphere is, and what the end-user is with capacity of decision responsibility that can affect safety and quality of work [2]. The answers to that can clarify the role of human work in the increasingly automated spaces.

Social aspects related to new concepts on the complex work environments (CWE) will be analysed, especially those that configure the design of work organisation systems with automated equipment. The concept of autonomous systems (AS) is one of that group. In work environments with high levels of automation, the work with AS (autonomous robots, auto-guided vehicles or AGV, integrated manufacturing systems, work companions) represents specific options in the design of workplaces. In the epistemological tradition of "social construction of technology" [3, 4], technology can be defined not as a product (or an equipment) designed and marketed, but as a social relation that integrates the equipment and working tools, the operators and the material to be transformed.

From these social relations, the concepts of "agents", "co-working" or "human-centred technical systems" reveal new dimensions related to HCI. This means that the design of human-centred technical systems is dependent on specific social relations and is not a mere technical issue. Those technical systems (robots, NC machine tools, AGV) are not designed with more sophisticated developments of increased communication systems (machine–machine communications, but also machine–human communication), but those developments have an intention. Why such systems are designed in that way? Are there alternatives? Why they are not implemented? The answer to these questions rely on social principles, on defined strategies for organisational development and even the human resources management (HRM) options obey to such rationale.

The HCI concept should not be only defined on the base of configurations of technical systems, but more in terms of organisational configurations, because this concept of organisational configurations under CWE leads to new pattern of human–machine interfaces. Why? Because the design of work organisation implies the definition of tasks to be accomplished by humans with major or less autonomy, using tools and intelligent equipments. That is why HCI should be connected with approaches on organisation theories in industrial work systems.

Some authors (as Dhondt et al. [5], based on the model of Karasek and Theorell [6]) use the following distinction in a study for the European Foundation on work organisation and technology:

- Active work organisation, where the workers experience higher levels of demands but at the same time enjoy enough opportunities to control these demands.
- Passive work organisation, where workers experience no job demands and have no control of possibly changing features of the work situation.
- High-strain work organisation, where the workers experience high demands but have no way of controlling what happens. They have to passively adapt to ever-changing and possibly conflicting demands.
- Low-strain work organisation, where workers experience low demands and have enough control to deal with problems.

In the European Foundation survey (p. 23, [5]), it was verified that 22 % of answers were related to an "active work organisation" in Europe. More than the half of the respondents mentioned the identification of their jobs as "low-strain work organisation" (25.6 %) and a "passive work organisation" (26.6 %). This means that (at least in Europe) most workers are in simple and passive work organisation systems. But a large number of them experience higher levels of job demands and can control them. This would be applied to workplaces with higher-level technicity. The examples of industrial automation and operation of robots are usually in this framework.

In this sense, our hypothesis is that robotics is in a development process that has important implications on the human interaction possibilities: the information becomes more formalised and the process can be standardised. That can have obvious implications in the way human resources would be managed. The risk for a less reflexive work organisation model is high when the standardisation process is fostered by the technical features [4, 7]. However, is acknowledgeable two major alternatives. In some (few) cases, it is possible that the high qualified human interaction can intervene in the production process and control it from a higher level. In other cases, low-skilled operation only is able to monitor the process with less interaction, and the human workplaces can become irrelevant. These different results depend on the chosen organisational model.

6.3 Robotics and Job Design

Hereby, we will use the case of robotics to exemplify the issues related to the use of automation in working environments and the emergence of new HCI approaches that would include social implications. Some of the most critical approaches on the development of robotics lay on the question if their use may lead to labour displacement or substitution. Would job profiles improve as robots take over dangerous, dull and dirty jobs, as promises for the adoption of these technical changes?

Following this direction, it would be necessary to know if it can lead to an extension of the digital divide. Or does the introduction of robotics create new forms of work organisation? Or is it done for repetitive tasks? And who is the "end-user" of robotics? The operator or the programmer? Actually, the answer of these questions marks a debate field of social sciences for several decades [8, 9]. The trends show that the "classical" questions about the social impacts still remain important. But the most recent developments on robotics demonstrate the need to revisit those debated concepts and to increase the collaboration with social scientists among the engineering and computer scientist research teams.

A survey for the European Foundation for Improvement of Working and Living Conditions mentioned that the use of machine technology shows a high correlation with short and long repetitive, monotonous work. Machine technology seems to be a requirement for such repetitive work (p. 18, [5]). In fact, the authors underline that there is a weak correlation between use of machine technology and high-strain working situations ($r = 0.17$). Also, a small correlation exists between active work situations and use of computers. This means that the way in which work is organised in organisations does not coincide with the use of technology (p. 22, [5]).

However, are we talking about a new empirical field? There are several empirical studies on HCI applied to robotics, or on CWS, or even on human interaction with AS. But studies on technology assessment of industrial robotics and AS on manufacturing environment are not so frequent, and they should also focus on the human involvement strategies in organisations. Such empirical field would need as well evidences from the human resource management sciences. And again, few research is being done in this knowledge field.

To add more gaps into this topic, a needed participatory strategy implies a new approach to workplaces design. The involvement of human agents in the decision process needs an *ex ante* definition of features and principles for a work place design. Such design (with involvement of robot operator in the decision process) implies more interaction with robots, different competences and responsibilities. The research on software development to integrate knowledge based systems into automated and programmable machinery is also an empirical field where the space of tacit knowledge can raise new problems for the formalised knowledge. Several sociological studies were aiming those topics, but almost no research was done in the framework of complex manufacturing systems environments [7, 10, 11].

In this way, we can conclude that the knowledge about the organisational challenges outcomes under the framework of technological developments found important gaps about the manufacturing industry sector experiences, especially when those developments are related to robotics. One can use research findings from management sciences, industrial sociology, social psychology, but there are few empirical studies on that. Eventually, technology assessment exercises can produce more scientific material on the social and organisational implications of the development of human and robot interactions [2].

6.4 Some Final Remarks

The study of the dissemination of robots in production activities leads us to understand possible implications to the labour market. In fact, the volume of introduction of new robots in manufacturing industry is much higher than with service robotics, or even with professional service robots [12, 13]. However, expectations point out to a clear increase in this market. Automotive industry sector is the one where most IR are introduced, and the one with highest density. Thus, the type of AS used with interaction with humans can indicate what are the social needs associated to the design of technology. For that reason, studies on technology assessment of robotics and AS on manufacturing environment should also focus on the human involvement strategies in organisations [2].

A needed participatory strategy implies a new approach to workplaces design, as above was already mentioned. But was must also be said, is that it also implies the definition of principles to regulate the means of involvement of humans in the control of those equipments as system agents. With an increase in the number and complexity of those interfaces, the capacities of human intervention can become limited, originating further problems [14].

Some new research questions can be presented as about new concepts dealing with the relation of automated systems and job design. At a first overview, it would seem that is still the same type of issues that are been revisited in the last years [15, 16]. But is not yet clear which concepts have been accepted and which not. The discussions reveal that further empirical approaches are still needed in this field. Hereby, the guiding hypotheses agree with the conviction that working with autonomous agents is increasing the safety problems and imply a shift in the framework of the relation of humans with their work environments [17, 18]. New questions must be developed to understand newly emerging problems of allocating, monitoring and diagnosing responsibilities in such systems [19, 20].

On the one hand, the technology design does not have specific consideration for organisational and social dimensions. The major IR manufacturers do not consider those dimensions. This can lead to further problems on systems implementations in CWE. The workplace design under such environments implies more interaction with robots, different competences and responsibilities [2, 20]. As said before, the non-determinist interaction is a human feature. And the complexity is too great to

develop those features on machines. Thus, the risk of trying it can be not worth, and it can bring additional safety problems that are not yet controlled. It is, however, interesting to develop and apply to some AS those features in given sectors as mining, medical, planetary, rescue or inspection applications [21, 22].

On the other hand, is not clear which kind of discussion framework is the social science dealing with under this relationship. The concept of "new working environments" gave considerable attention to the challenges of the increased competencies of people working together with automated technologies. But in the last years social sciences did not produce further knowledge on such issues. Nevertheless, non-technological dimension (sociological, psychological, cultural and ethical) of technology design should be recognised and taken into consideration [23, 24].

In such conditions, it can be questionable how far is possible to implement real interactive procedures. The same would be applied to the use of HRI integrating organisational dimensions. One cannot really speak about "common aims" in co-working environments integrating humans and AS [11, 15, 18, 25]. When one takes workgroup strategies the concept of "common aim" must be taken. Thus, how could it be possible to design co-working environments without workgroup strategies? We must conclude that would not be rationally possible.

Today, one can understand that is possible and necessary the wider use of the anthropocentrism concept applied to the production architectures, although intrinsic difficulties can be evident. These difficulties rely either on the side of organisational design (that include co-working features) or on the side of technical development. This means that industrial companies (automotive, electronics, metal engineering) and service organisations (health, logistics) are still framed under organisational models that constrain the possibility to redistribute the decision process to lower hierarchical levels, as for robot operators [26–28].

It is emerging, however, a new indication of the value of intuitive capacities and human knowledge in the optimisation and flexibilisation of the manufacturing processes. These dimensions were not usually considered [29, 30]. But when there are new risk situations that occur with the use of AS (especially IR and SR), those can be elements to consider in the design process [5, 25, 31]. It is becoming evident that is necessary to take into consideration qualitative variables in the definition and design of robotic (IR/SR) systems, jobs and production systems [8, 32, 33].

It is already possible to implement knowledge sharing at the workplace. But that is not always recognised when applied to IR in manufacturing environments [34–36]. An improved "intelligent" workplace should mean not only an increased capacity of the manufacturing system (that would include robotics, numerical control machine tools, logistics and complex work flows) in terms of programming, system control or environment data processing. It should also mean the involvement of operators that intervene in the different manufacturing phases. They should become more "system operators" and less "machine operators". The issue of responsibility in the decision process is still not clear: in increased self-controlled system who takes responsibility for unexpected events? Are AS

co-workers of organisational managers? Will it be possible for autonomous agents to achieve tacit knowledge? The answer to such questions need further research evidences [37, 38].

To summarise we can say that the status of the scientific research on these issues is no longer focused on the human aspects of the manufacturing automation concepts. The focus has been taken on the human–machine interfaces and on the self-governance of AS. In other words, the focus is on the relation between technology and social dimensions not as separate entities, but integrated in the design of an interaction system. That means the knowledge and communication structures are elements of the organisational technology system [9, 39]. Thus, competence requirements and skill need for the workplaces interacting (or co-working) with AS are as important as the product manufacturing system design or the integration process that provides further production flexibilities [8, 33]. Those perspectives should be analysed critically on future research on AS and on HRM applied to technological developments at the workplace.

References

1. Ejiri, M. (1996). Towards meaningful robotics for the future: Are we headed in the right direction? *Robotics and Autonomous Systems, 18*(1), 1–5.
2. Moniz, A. B. (2012). Anthropocentric-based robotic and autonomous systems: Assessment for new organisational options. In M. Decker, & M. Gutmann (Eds.), *Robo- and informationethics: Some fundamentals* (LIT, Zürich/Berlin, pp. 123–157). [http://ideas.repec.org/p/ieu/wpaper/27.html].
3. Bijker, W. E., Hughes, T. P., & Pinch, T. (1987). *The Social Construction of Technological Systems*. Cambridge, MA: MIT Press.
4. Winner, L. (1993). Upon opening the black box and finding it empty: Social constructivism and the philosophy of technology. *Science, Technology, & Human Values, 18*(3, Summer), 362–378.
5. Dhondt, S., Kraan, K., & van Sloten, G. (2002). *Work organisation, technology and working conditions* (p. 70). Luxembourg: Office for Official Publications of the European Communities. European Foundation for the Improvement of Living and Working Conditions.
6. Karasek, R., & Theorell, T. (1991). *Healthy work: Stress, productivity, and the reconstruction of working life*. New York: Basic Books.
7. Huws, U. (Ed.) (2006). *The transformation of work in a global knowledge economy: Towards a conceptual framework* (WORKS, Leuven, 249 pp).
8. Soete, L. (2001). ICTs knowledge work and employment: The challenges to Europe. *International Labour Review, 140*, 2.
9. Krings, B. (2006). The sociological perspective on the knowledge-based society: assumptions, facts and visions. *Enterprise and Work Innovation Studies, 2*, 9–19.
10. Paulos, M. R., & Moniz, A. B. (2008, Nov). Fragmentation? The future of work in Europe in a global economy: the WORKS final international conference debate. *Enterprise and Work Innovation Studies*, *4*(4), 167–169.
11. Weiss, A., Wurhofer, D., Lankes, M., & Tscheligi, M. (2009). Autonomous vs. tele-operated: How people perceive human-robot collaboration with HRP-2. In *HRI'09*: *Proceedings of the 4th ACM/IEEE international conference on human robot interaction* (ACM, New York, pp. 257–258).
12. IFR-International Federation of Robotics (2011). *World Robotics 2011* (IFR).

13. IFR-International Federation of Robotics (2012). *World Robotics 2012* (IFR).
14. Corbett, J. M. (1990). Human centred advanced manufacturing systems: From rhetoric to reality. *International Journal of Industrial Ergonomics, 5*(1990), 83–90.
15. Bernstein, D., Crowley, K., & Nourbakhsh, I. (2007). Working with a robot: Exploring relationship potential in human–robot systems. *Interaction Studies, 8*(3), 465–482.
16. Heyer, C. (2010). Human-robot interaction and future industrial robotics applications. In *2010 IEEE/RSJ: Proceedings of the International Conference on Intelligent Robots and Systems* (IEEE, Taipei, pp. 4749–4754).
17. Uden, L. (1995). Design and evaluation of human centred CIM systems. *Computer Integrated Manufacturing Systems, 8*(2), 83–92.
18. Haddadin, S., et al. (2011). Towards the robotic co-worker. In C. Pradalier, R. Siegwart, & G. Hirzinger (Eds.), *Robotics Research* (pp. 261–282). Berlin, Heidelberg: Springer.
19. Kobayashi, Y., et al. (2012). Multi-tasking arbitration and behaviour design for human-interactive robots. *International Journal of Systems Science*. doi:10.1080/00207721.2011.625477.
20. Barthélemy, J. P., Bisdorff, R., & Coppin, G. (2002). Human centred processes and decision support systems. *European Journal of Operational Research, 136*, 233–252.
21. DoD—Department of Defence (2012). *Unmanned systems integrated roadmap FY2011–2036*, Reference Number: 11-S-3613, Washington.
22. EUROP (2009). *Robotic visions to 2020 and beyond—The strategic research agenda for robotics in Europe*, 07/2009.
23. Huws, U., & Ramioul, M. (2006). Globalisation and the restructuring of value chains. In U. Huws (Ed.), *The transformation of work in a global knowledge economy: Towards a conceptual framework* (pp. 13–28). Leuven: WORKS.
24. Groom, V. (2009). I am my robot: The impact of robot-building and robot form on operators. In ACM: Proceedings of HRI'09 (ACM), 11–13 March 2009, La Jolla, CA.
25. Kochan, A. (2006). Robots and operators work hand in hand. *Industrial Robot: An International Journal, 33*(6), 422–424.
26. Moniz, A. B., Krings, B. J., Van Hootegem, G., & Huys, R. (2002). Technological practices in the European auto industry: Exploring cases from Belgium, Germany and Portugal. *Int. Journal of Automotive Technology and Management, 2*(1), 84–100.
27. Lenz, C. (2011). *Context-aware human-robot collaboration as a basis for future cognitive factories*. PhD thesis, Technische Universität München, 145 pp.
28. Ribeiro, L., Barata, J., & Barreira, P. (2009). Is Ambient Intelligence a truly Human-Centric Paradigm in Industry? Current research and application scenario. *Enterprise and Work Innovation Studies*, *5*, 25–35 (IET).
29. Drury, J., Scholtz, J., & Yanco, H. (2004). *Applying CSCW and HCI techniques to human-robot interaction*, report (Case #04-0166), Bedford MA, MITRE.
30. Morioka, M., & Sakakibara, S. (2010). A new cell production assembly system with human–robot cooperation. *CIRP Annals-Manufacturing Technology, 59*(2010), 9–12.
31. Thrun, S. (2004). Toward a framework for human-robot interaction. *Human–Computer Interaction, 19*(1–2), 9–24.
32. Gorle, P., & Clive, A. (2011). *Positive impact of industrial robots on employment* (IFR/Metra Martech, London, 66 pp.).
33. Ramioul, M. (2006). Organisational change and the demand for skills. In U. Huws (Ed.), *The transformation of work in a global knowledge economy: Towards a conceptual framework* (pp. 97–118). Leuven: WORKS.
34. Wagner, J. J., Van der Loos, H. F., & Leifer, L. J. (2000). Construction of social relationships between user and robot. *Robotics and Autonomous Systems, 31*(2000), 185–191.
35. Sampaio, J., & Moniz, A. B. (2007). Assessing human and technological dimensions in virtual team's operational competences, MPRA Paper 6942.
36. Williams, J. S., & Harrison, M. D. (1999). Requirements for prototyping the behaviour of virtual environments. Human-Computer Interaction Group, Department of Computer Science, University of York.

37. DSB-DoD—Defence Science Board (DSB). Department of defence (2012). Report of the DSB task force on the role of autonomy in DoD systems, Washington.
38. Medeiros, D., & Sadowski, R. (1983). Simulation of robotic manufacturing cells: A modular approach. *Simulation, 40*(3), 3–12.
39. Yee, N., Bailenson, J. N., & Rickertsen, K. (2007). A meta-analysis of the impact of the inclusion and realism of human-like faces on user experiences in interfaces. In *CHI'07: Proceedings of the SIGCHI conference on human factors in computing systems* (ACM, New York), San Jose, CA.