Adding a strategic edge to human factors/ergonomics: Principles for the management of uncertainty as cornerstones for system design

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A B S T R A C T

It is frequently lamented that human factors and ergonomics knowledge does not receive the attention and consideration that it deserves. In this paper I argue that in order to change this situation human factors/ergonomics based system design needs to be positioned as a strategic task within a conceptual framework that incorporates both business and design concerns. The management of uncertainty is presented as a viable candidate for such a framework. A case is described where human factors/ergonomics experts in a railway company have used the management of uncertainty perspective to address strategic concerns at firm level. Furthermore, system design is discussed in view of the relationship between organization and technology more broadly. System designers need to be supported in better understanding this relationship in order to cope with the uncertainties this relationship brings to the design process itself. Finally, the emphasis on uncertainty embedded in the recent surge of introducing risk management across all business sectors is suggested as another opportunity for bringing human factors and ergonomics expertise to the fore.

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1. Introduction

Dul et al. (2012) have provided a very timely and accurate summary of the current status of human factors/ergonomics and have suggested a number of ways forward. Building on their excellent work, I begin by restating the fundamental objective of human factors/ergonomics, which is to contribute to human performance and well-being by establishing and implementing integral system design. Given the clear relevance of this objective for work organizations and society more broadly, the main question addressed by Dul et al. (2012) is that of why knowledge in human factors and ergonomics has not yet found wide-spread acceptance and application. They provide four answers to this question: many relevant stakeholders are not aware of this knowledge; the knowledge is not readily available in design projects; the knowledge is not sufficiently singled out; due to its multi-disciplinary sources the knowledge is multi-faceted and ambiguous. They further argue that the value of human factors/ergonomics is more easily apparent to front-line system users who directly benefit from it but themselves have little influence over design decisions. Those who have more power like decision makers in work organizations and system developers tend to pay much less attention to human factors and ergonomics issues due to the four reasons mentioned above.

In order to make decision makers and system developers more aware of the value of existing knowledge in human factors/ergonomics and help them apply it more effectively, Dul et al. (2012) suggest to improve communication and build partnerships with stakeholders and to promote high-quality standards in application, education, and research in system design. In this paper, I take a complementary approach by arguing that not only better marketing and higher standards for human factors/ergonomics knowledge are required for improved system design, but that system design needs to be positioned as a strategic task based on a conceptual framework incorporating both business and design concerns. Judging from consumer products like mobile telephones or cars and some high-risk technologies like aircraft where the strategic importance of system design is already understood, system design will benefit greatly and with it the acceptance and application of human factors/ergonomics knowledge from such a change in perspective.

The suggested approach reaches beyond what Dul and Neumann (2009) outline in their article on the contributions of ergonomics to company strategy. In addition to developing practical links between what ergonomists do and what is done at a strategic level in companies, a common conceptual framework for a strategic approach to system design is required. Only if human
factors/ergonomics knowledge becomes an integral part of strategic decision-making by directly contributing to the fundamental business concern of gaining and maintaining a competitive edge, will its significance not be challenged any longer. It is argued here that the management of uncertainty can serve as such a common framework due to the pervasiveness of uncertainty both as a concept in organizational and design research and as a day-to-day challenge in business operations. Furthermore, uncertainty impacts individual and company performance as well as individuals’ health and well-being, thereby incorporating both sets of outcomes human factors/ergonomics is concerned with and providing a bridge to and stronger emphasis of performance-related outcomes from a business perspective.

In the following sections, the concept of uncertainty and approaches to the management of uncertainty are discussed. An example is provided of how human factors/ergonomics issues in a railway company have been directly tied into strategic tasks at company level by framing them in terms of uncertainty management. Subsequently, system design is discussed in view of the relationship between organization and technology more broadly. System designers need to be supported in better understanding this relationship, which entails high levels of uncertainty for design itself as the use patterns and organizational effects of technology are only partially predictable. Finally, risk management – which is directly related the management of uncertainty - is suggested as another opportunity for bringing human factors and ergonomics expertise to the fore due to the pervasive efforts across all business sectors to better handle risks.

2. Uncertainty and its management

2.1. Defining uncertainty

Uncertainty – or “not knowing for sure” – is ubiquitous in organizations. Daily business is impacted by uncertainty just as much as strategic decisions. Moreover, all parts of business operations are affected, though possibly in varying degrees: Supply relationships and production tend to be manageable along more predictable lines than new product development or opening new markets for existing products. Uncertainty is also experienced by the individual members in organizations, not only through the work task at hand, but also in the personal employment relationship, manifesting itself for instance in job insecurity.

Uncertainty can arise due to the absence of information needed for a task (Galbraith, 1973) or due to the ambiguity of existing information (Weick, 1979; Daft and Lengel, 1984). Either way, uncertainty implies a lack of predictability and transparency, thereby compromising the prerequisites for effective control (Brehmer, 1992; Sutton and Kahn, 1987). Detrimental effects for performance and individual well-being resulting from uncertainty and the ensuing lack of control are well documented (e.g., Gilboa et al., 2008; Van der Doef and Maes, 1999). As a consequence, organizations’ and individual decision-makers’ foremost aim is to reduce uncertainty. However, the reduction of uncertainty comes with certain costs, while on the other hand maintaining or even increasing uncertainty may have benefits, as evidenced most obviously in starting new business ventures. Effective management of uncertainty should therefore always entail a systematic analysis of the uncertainties at hand as well as a comprehensive consideration of costs and benefits for reducing, maintaining, and increasing uncertainty.

2.2. Balancing different modes of uncertainty management

As a starting point for making strategic decisions on how an organization should approach uncertainties and whether particular uncertainties should be reduced, maintained or increased, two basic modes of uncertainty management can be constrained: minimizing uncertainties versus coping with uncertainties can be contrasted (Grote, 2009, 2011).

Scientific treatment of organization design at the turn of the 20th century (Taylor, 1911; Weber, 1947) was built on the assumption that organizations are closed systems, thereby protected from external uncertainties. Internal uncertainties were to be minimized by minute planning and continuous monitoring of the execution of these plans, providing minimal degrees of freedom to the people in charge of carrying out the plans and taking any deviation from the plans as signs for the necessity of even more planning and monitoring. The Fordist production lines are a prime example of the minimizing uncertainties approach. They were tailored to mass production of standard products, that is: Model T in black. With the acknowledgement of the open system nature of organizations the minimizing uncertainties approach continued to be followed and even gained in fervour in order to keep systems under control (Senge, 1990). Weitz and Shenhav (2000) have suggested that engineers used their success in handling technical uncertainties to expand their professional domain to include the reduction and elimination of organizational uncertainties as well. As the minimizing uncertainties approach promises maximum control over work processes and outcomes, it is still the favoured approach in many organizations.

A fundamentally different approach which has been promoted by organization theorists and work scientists for several decades now is to enable all members of an organization to cope with uncertainties locally and to rely on feedback control (e.g., Perrow, 1967; Weick et al., 1999). From this perspective, planning is understood primarily as a resource for situated action (Suchman, 1987), not as a blueprint for centrally determined and monitored action. Local actors need to be given as many degrees of freedom as possible, achieving concerted action mainly through lateral, task-induced coordination. Disturbances are regarded as opportunities for use and expansion of individual competencies and for organizational innovation and change. The principles of socio-technical design as formulated by Cherns (1987) and extended by Clegg (2000) provide a good summary of the core ideas of this approach, especially the principles of minimal critical specification for work processes and task allocation, of role breadth to ensure multifunctional expertise, and of controlling variances at their source.

Much of the earlier literature in organization theory was aimed at developing contingency models for deciding between the minimizing and coping with uncertainty approaches in light of the types and amounts of uncertainty a particular organization is faced with (e.g. Burns and Stalker, 1961; Thompson, 1967; for a comprehensive review see Wall et al., 2002). The most basic understanding of these contingencies is that minimizing uncertainties only works when the overall level of uncertainties an organization is confronted with is low. With higher levels of uncertainties, any attempt to design them out of the system will fail and therefore the system has to be enabled to cope with uncertainties locally.

More recently, research has been concerned with showing the need and also the possibilities for overcoming the dichotomy between minimizing of and coping with uncertainty. In 1976 Weick already argued that most organizations aim to achieve what he called loose coupling, that is the concurrence of autonomy and dependence and thereby also a mix of coping with and minimizing uncertainty. In 1991, March wrote an influential article, approaching the same issue from the perspective of learning in organizations. He argued that a balance is needed between exploration of new possibilities, concerned with search, variation, experimentation and risk taking, and exploitation of old certainties in terms of
refinement, implementation, and efficiency. The overarching concern is the necessity to balance stability and flexibility, which each offer unique advantages at the organizational, team and individual level (Fig. 1; Farjoun, 2010; Leana and Barry, 2000; Manz and Stewart, 1997). The high levels of routine, standardization and formalization which create stability generally enhance predictability and control and reduce the need for ad hoc coordination. The capacity for flexibility and change, on the other hand, allows for learning and ad hoc adaptations to new and variable demands. To be able to reap the benefits of both appears highly desirable.

How concurrent flexibility and stability are to be achieved, though, is much debated. One basic question is whether there should be separate entities in organizations charged with establishing and maintaining stability and flexibility respectively or whether this can be achieved within a single organizational entity such as a team or a department (Gupta et al., 2006). Furthermore, the understanding of flexibility and stability as two ends on a continuum where the concurrence of both represents some kind of midpoint has recently been challenged by the proposal to view flexibility and stability as a co-existing duality (Farjoun, 2010; Grote et al., 2012).

In the following I argue that this fundamental concern - balancing stability and flexibility in the face of ubiquitous uncertainties through adequately managing these uncertainties - should be used to embed human factors and ergonomics within a larger systemic perspective and increase its strategic relevance.

3. Embedding system design in the management of uncertainty

The proposed approach builds on the premise that the overall objective in individual and organizational decision-making is to gain and maintain control in order to achieve desired goals. For this purpose decision-making on the management of uncertainty has to happen in ways that foster an appropriate balance between stability and flexibility in organizational functioning taking into due consideration the nature of sociotechnical and environmental contingencies. Decision-making should entail four basic steps: Analyzing costs and benefits of reducing uncertainty; analyzing costs and benefits of maintaining or increasing uncertainty; exploring belief systems in the organization related to managing uncertainties; discussing anticipated effects of the recommendations derived in steps 1 to 3 and making decision on managing the particular uncertainty at hand (for more detail see Grote, 2009, 2011).

In order to perform these four steps, an uncertainty landscape has to be drawn up that contains as many of the relevant internal and external uncertainties as possible. Subsequently, a systematic assessment is performed regarding the costs and benefits involved in reducing, maintaining or increasing the identified uncertainties. This assessment is complemented by a reflection of belief systems and their impact on cost-benefit assumptions for the different ways of handling uncertainty. Beliefs about central controllability of production processes, for instance, may easily produce an overly optimistic view on opportunities for minimizing uncertainty. Finally, the discussion on costs and benefits of different management approaches will be summarized for all uncertainties concerned and decisions taken on the most appropriate approach. The overall aim is to achieve a balance of stability and flexibility fitted to the particular needs of the organization. The decisions made at this conceptual level then serve as input for the more concrete system design process which will be conducted with existing methods and instruments in human factors and ergonomics.

The decision process should be conducted by a team that includes the organization’s experts of the domains to be covered (for instance, process engineers when a new automation concept is to be developed), representatives of the people affected by the decisions (for instance, operational personnel), and the actual decision-makers (for instance, the head of production). Depending on how broad the chosen content domain is the four steps can be discussed within a few hours, or they might form the basis of a project running weeks or even months.

3.1. An example: managing uncertainty in a railway company

The example (taken from Grote, 2009, 2011) is situated in a railway company, which like the railway industry in general is faced with many new uncertainties through technological developments, privatization, stiff competition, especially regarding carriage of freight, and growing capacity demands. The safety department in this particular railway company was charged with evaluating the effects of all these developments on the capabilities and needs of different groups of employees for performing their jobs effectively and safely. It was decided to perform this assessment by means of a series of workshops in which the management of uncertainty was used as a guiding principle. As no one specific decision had to be made, but rather an evaluation of anticipated new uncertainties and their potential effects was to be carried out, costs and benefits of reducing, maintaining and increasing uncertainty were discussed quite broadly for different business operations.

As a first step, the technological and organizational changes which were underway or planned for the next ten years were collated, highlighting three particularly important clusters of changes: increasing automation of train control, centralization of traffic control, and higher traffic density. In two one-day workshops with representatives from safety, quality management, infrastructure, train operation, and maintenance, the effects of these changes on the task profiles for train drivers, signallers, shunters, and maintenance and construction personnel were assessed. Using the KOMPASS method and the design criteria defined there (Grote et al., 2000; Wäfler et al., 2003) as a general framework, each task profile was analyzed in detail in relation to assumed changes in complexity and uncertainty through increased automation and task interdependencies. For shunting, maintenance and construction, these analyses showed an increase in uncertainties related to managing task interdependencies within more interlinked and more tightly planned work processes. For train drivers, automation was considered to have the greatest impact, which in the long run was assumed to reduce train driving to mere supervisory control functions with the uncertainties particular to those functions like reduced system transparency and requirements for fast and flexible responses to non-routine events. Finally, for traffic controllers and signallers, it appeared that increased integration of traffic control in highly automated central control centres might lead to a new, more complex job profile for traffic controllers, and a less complex profile.
covering routine operation for the former signalers. While some workshop participants saw centralization resulting in fewer uncertainties for traffic controllers, others assumed that requirements for uncertainty handling might even increase as needs for local adaptations would remain and would be more difficult to handle in centralized control centres.

In the workshops, the central role of traffic control and of the changes in that function through centralization and automation became very obvious. Depending on how the changes in traffic control were to be implemented, uncertainties might be transferred to other actors and conditions for handling them might improve or worsen. One small example in this respect was an already implemented change in rules concerning shunting of trains onto occupied tracks. Previously, signalers were required to communicate to train drivers if the assigned track was occupied because the signal used for this operation is ambiguous and only conveys the maximum speed of 40 km/h to the train driver. With increasing traffic density and more traffic to be handled by signalers in more centralized control centres, this communication requirement was dropped leaving the train driver with insufficient information regarding adequate shunting speed. This problem was addressed by yet another change in rules which set the maximum shunting speed to 10 km/h in situations with particularly low visibility where train drivers have little chance to discover track occupation in time to reduce speed sufficiently. Thus, uncertainty was originally increased for train drivers and then partially reduced again.

In the discussions, the exploration of belief systems and their effects on perceived costs and benefits of the different ways of handling uncertainty happened more implicitly than explicitly. In the workshops and in the subsequent development of various guidelines, differences in preferences and beliefs regarding effective organizational design became apparent. However, instead of confronting the different views — for instance regarding the appropriate distribution of power and control between the different occupational groups — broad participation in guideline development was sought as a means to further collective sense-making and the building of shared belief systems. In organizations with a rationalist culture, as in this case, addressing belief systems in more implicit ways may generally be more effective than trying to discuss them directly.

Overall, the most significant concern that emerged in the workshops was the growing difficulty of managing task interdependencies due to the greater centralization of traffic control, fewer buffers in resource planning, and loss of shared understanding of work processes through divisionalization of the organization. Detailed analyses of the coordination required between job functions showed that there was considerable potential for unduly transferring uncertainties to other job functions, especially from traffic control to train driving and maintenance. In order to address these concerns, several measures were taken: more integrated training across company divisions, the development of a guideline for job and system design tailored to the needs of the different company divisions, and the development of a guideline for rule management in cooperation with the railway regulator. An important element of the rule management guideline as it now stands is a decision tree that helps to clarify the amount of uncertainty to be handled in a given work process, the possibilities for reducing that uncertainty, and the requirements for training and for support by fairly open rules in case the uncertainty has to be maintained (Grote et al., 2009).

Additionally and most importantly, an annual risk assessment was introduced that is to permit the monitoring of changes in the uncertainty landscape for different job functions and of (mis-)matches between requirements and capacity for handling those uncertainties. This risk assessment and technical and organizational measures derived from it are discussed with the executive board every year, thereby embedding human factors and ergonomics concerns in strategic decision-making at the highest level of the organization.

Concluding, the example provides a good illustration of three main advantages of the uncertainty management framework for system design:

- Due to its ubiquitous nature uncertainty serves well as a common frame of reference across different task domains and business functions and across operational and strategic levels of decision-making.
- Opening up the discussion to include options for reducing as well as for maintaining or increasing uncertainty permits a more comprehensive consideration of stability and flexibility demands in work processes and possible undue transfers of uncertainty between task domains and actors.
- The influence of implicit beliefs on the assessment of different design options is unearthed, thereby promoting an explicit debate of design principles and development of a shared perspective on means and outcomes of system design both operationally and strategically.

4. Uncertainties in the relationship between organization and technology

So far, I have argued that the management of uncertainty is a strategic concern to which human factors/ergonomics knowledge can contribute greatly. However, human factors/ergonomics based system design itself also requires adequate management of uncertainty, because the relationship between organization and technology is neither fully transparent nor predictable. Technology needs to be treated as both an independent and a dependent variable in system design. That is, technology changes organizations, but it is also deliberately chosen and changed by organizations. This was first demonstrated in the seminal work of the Tavistock group that brought about the original socio-technical systems design approach (Trist and Bamforth, 1951). The core design principle of the socio-technical systems approach as it was understood then, is the control of variances at their source (Cherns, 1987; Pasmore, 1988). This provides a very direct link to the management of uncertainty, even though the perspective suggested here is broader because strategic consideration of costs and benefits of uncertainties is included, while in socio-technical system design uncertainty is taken as operationally given.

In today’s human factors and ergonomics literature the term socio-technical system is ubiquitous, though often used without the conceptual understanding behind it. At the same time, this conceptual understanding has had a very strong influence on the early work in organization theory (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Thompson, 1967; Woodward, 1965) where uncertainty has become a core concept, but the link to technological design has been mostly lost. This is mainly due to the fact that in the early sociological work on organization theory technology was defined as the work people do (e.g., Comstock and Scott, 1977; Perrow, 1967). This definition impedes an independent consideration of the effects different designs of technology can have on people’s tasks and thereby also renders it difficult to derive design requirements, as acknowledged explicitly by Perrow himself a few years later (Perrow, 1983).

Over last decades, especially information and communication technology (ICT) has spurred renewed interest in the reciprocal interaction between organization and technology (for a conceptual overview see Leonardi and Barley, 2010). Following the stance
of technological determinism, some authors have argued that this technology will “automatically” further decentralized and democratic decision-making due to its capability to support lateral coordination within and across organizations and even societies (e.g., Sproull and Kiesler, 1991). As Clegg et al. (2006, p. 384) have phrased it: “the pen and the typewriter gave us bureaucracy; can virtuality give us democracy?” The empirical evidence indicates that ICT can in fact have democratizing effects, especially when it is employed to informate work processes rather than to automate them (Zuboff, 1988). Grote and Baitisch (1991) have pointed to a number of technical as well as organizational prerequisites for these effects to materialize, though, such as management support for less hierarchical decision processes and task-induced communication and cooperation needs. Their view on the effects of ICT aligns with the sociological perspective of adaptive structuration, which stresses human agency in selecting, interpreting and enacting opportunities created by technology (Boudreau and Robey, 2005; DeSanctis and Poole, 1994; Orlikowski, 1992, 2000). Technology from this viewpoint presents opportunities for structural change that can be expressed as the spirit of the technology (DeSanctis and Poole, 1994). This spirit is related to the designers’ intentions, but is not fully determined by them. Rather, it is a combination of the design metaphor underlying the system (e.g., electronic chalkboard), the specific features the system possesses and how these are named and presented, the appearance of the system through the chosen user interface, and the procedures for system instruction and training. The technology’s spirit will influence, but not determine, which of many possible alternatives will actually emerge as the dominant use patterns.

4.1. Consequences for system design following from adaptive structuration

Mirroring Dul et al.’s (2012) critique of sociologically and anthropologically based research lacking an “action view”, Leonardi and Barley (2010) have argued that the debate about technological determinism and the corresponding social science research demonstrating the intricate relationship between technology and organization has to date not produced much knowledge that can directly inform system design. System designers are confronted with the necessity of gaining a thorough understanding of the technological potentials as well as the forces operating in the organization in favour of and against realizing these potentials (Klein and Sorra, 1996). These forces are very strongly linked to assumptions about appropriate management of uncertainty and about the role humans can and should play in work systems including their interaction with ever more complex technology in fulfilling this role (e.g., Boy and Grote, 2011; Hollnagel and Woods, 2005; Parasuraman et al., 2000; Woods and Branlat, 2010; Young and Stanton, 2007). Human factors and ergonomics methods need to reach beyond the one-sided “fit the task/the environment to the human” perspective and help in making these more fundamental assumptions explicit in order to improve system design and bring the strategic relevance of system design to the fore. In applying our own KOMPASS method (Grote et al., 2000; Wäller et al., 2003) we found that it had its main impact through doing exactly that. Provoking controversial discussion of fundamental issues of managing uncertainty – specifically the distribution of control and responsibility in organizations and the role that technology can and should play in organizations – helped in developing a more comprehensive design philosophy that was shared and supported by the whole design team.

At the same time, leaving technological determinism behind means for system designers to embrace many more uncertainties in the design process itself because the lack of predictability of use patterns and organizational effects of technology is acknowledged from the start. It is therefore important to consider how the design process itself can be designed according to different approaches to managing uncertainty (Grote, 2004, 2009). How much participation by different stakeholders and how much openness for different solutions is sought, for instance, are indications of different ways of handling uncertainties. A design process can be turned into a mechanistic fulfilment of project management requirements aimed at minimizing project risks. It can also be an open search for novel solutions acknowledging the necessity to handle potentially vast amounts of uncertainties in order to achieve innovation.

4.2. Accountability for the impact of system design

When technology is considered as a causal agent producing predictable impacts in organizations, then responsibility for these effects lies with whoever made the decision on which technology to introduce where. Which changes are created can only be influenced by stopping, slowing or accelerating the introduction of a particular technology. From an organizational imperative position (Markus and Robey, 1988), managers and designers have a strong influence on the effects of technology, for instance, by making decisions about the specific features of technical systems, improving the design of features, and different implementation strategies and processes. Consequently, everybody involved in making and carrying out these decisions is accountable for the technology’s effects in the organization.

Adaptive structuration emphasizes emergence as the main causal mechanism, that is, the effects of technology are attributed to an unpredictable interaction of technological features and actors’ intentions and behaviours. No definite statements on the appropriate distribution of responsibility can be derived from this perspective. If effects are truly unpredictable then systematic intervention is not possible and responsibility for the technology’s effects cannot be assigned. Recently, this issue has been taken up by Suchman (2002) in her discussion of located accountability. She argues that the fact that knowledge and practice are distributed and that no one has the overall picture does not relieve anyone of responsibility, but makes everybody personally responsible for what lies in their reach. Boos and colleagues have followed this reasoning and have developed a conceptual framework and practical instruments for designing “controllable accountability” into systems, in their case specifically RFID-based ubiquitous computing applications (Boos et al., 2012; Boos and Grote, 2013).

5. From uncertainty management to risk management

Human factors/ergonomics knowledge and methods have probably been employed most extensively for systems that entail major risks for humans and the environment. For these systems the significance of ensuring working conditions that allow human operators to bring all their capacities to bear is most evident. The example presented in Section 3.1 of applying an uncertainty management perspective to system design at a strategic level in a railway company concerns exactly that kind of an organization. However, in the wake of major accidents and crises in various industrial domains over the last decades, awareness has risen for the importance of managing risks in a proactive and systematic fashion across a much broader range of organizations (Power, 2007). Risk management is in itself probably one of the fastest growing business fields.

In the most basic sense, risk management entails the identification and evaluation of risks, measures for handling the risks, and
risk communication (Renn, 2008). Human factors/ergonomics knowledge and methods can clearly inform all of these aspects of risk management and have done so in the past, but mainly for the so-called high-risk industries like aviation, nuclear power, chemical production, and more recently medicine. How human factors and ergonomics may reach into the design of systems in the financial services industry has been demonstrated in a recent book by Sundström and Hollnagel (2011). MacKenzie (2006) also provided a fabulous account of how technology has shaped risk-taking in the financial sector by seemingly increasing control over highly complex financial transactions, thereby presenting another impressive example of the complex relationship between technology and organization.

The management of uncertainty framework may help to further broaden the reach of human factors/ergonomics knowledge into the domain of risk management. Uncertainty can easily be linked to risk in its most basic form as an uncertain event or in more specific definitions of risk such as the product of probability and damage. Uncertainty in terms of lacking or ambiguous knowledge can be regarded as the “neutral” source of risk, as it may concern hoped for just as much as feared outcomes. Uncertainty implies that predictability and transparency as crucial prerequisites of control are reduced, which leads to insufficient means of influence for either avoiding damages or realizing opportunities. Power (2007) postulates that uncertainty is transformed into risk when it becomes an object of management. When uncertainties are managed well, a basic prerequisite for good risk management is established. Following this line of thinking, I postulate that human factors/ergonomics could gain momentum when its relevance for risk management across all types of industries and all types of risks well beyond occupational safety is demonstrated more explicitly and more boldly.

6. Conclusion

It is frequently lamented that human factors and ergonomics knowledge does not receive the attention and consideration that it deserves. In this paper I have argued that not only better marketing and higher standards for human factors/ergonomics knowledge are required to change this situation, but that system design needs to be positioned as a strategic task. Furthermore, I have argued that this is best accomplished by developing a conceptual framework that incorporates both business and design concerns. The management of uncertainty was presented as a strong candidate for such a framework due to the pervasiveness of uncertainty as a concept in organizational and design research and as a day-to-day challenge in business operations. Moreover, uncertainty impacts individual and company performance as well as individuals’ health and well-being, thereby strengthening the conceptual link between these two outcomes. An example was discussed where human factors and ergonomics topics were approached in a comprehensive and highly influential manner in a railway company by employing the management of uncertainty framework. The suggested approach was then reflected upon in light of research on the intricate interaction between technology and organization more broadly. System designers need to be supported in better understanding this interaction, which in fact increases uncertainty in the design process itself. This uncertainty requires careful management in order not to have designers shy away from it and fall back on a technologin deterministic stance. Finally, it was postulated that the current emphasis on risk management across all business sectors is yet another opportunity for human factors and ergonomics to gain momentum because well-managed uncertainties are a crucial prerequisite for good risk management.

References
