

Prospective ergonomics: origin, goal, and prospects

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Abstract. So far ergonomics has been concerned with two categories of activities: correction and design. We propose to add a third category: prospection, and by so doing, we introduce a new series of activities that opens up the future of ergonomics. Corrective ergonomics relates to the past and comes with a demand and a client. It is turned towards the correction of existing situations and aims to reduce or eliminate problems. Here, after delimiting and defining the problem, the challenge is to find the best solution. Ergonomics for design relates to the present and also comes with a demand and a client. It is turned towards the design of new artefacts that have already been identified by a client, and that will allow users to do some activity and attain their goals. Here, after defining the scope of the project and the functional requirements, the challenge is to do the best design. Finally, prospective ergonomics relates to the future and does not come with a demand and a client. It is turned towards the creation of future things that have not been identified yet. Here the challenge is to detect existing user needs or anticipate future ones, and imagine solutions. These three categories of activities overlap and are not exclusive of each other. In this paper we define prospective ergonomics and compare it with corrective ergonomics and ergonomics for design. We describe its origin, goal, and prospects, we analyze its impacts on education and practice, and we emphasize the need of new collaboration between ergonomics and other disciplines.

Keywords: Prospective Ergonomics, Studies of the future, User needs, Requirements, Creation, Innovation.

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1. Introduction

Ergonomists intervene more and more early in the lifecycle of systems and products. In this way, their work is changing, and now includes activities that deal with creation and innovation. In our opinion this announces the emergence of a new trend in our discipline that will grow rapidly and become significant in the next years. It is important for ergonomists to grab this new trend and prepare themselves for facing the challenge that comes with it.

In this paper we reflect on the future of ergonomics and strongly argue for the adoption of prospective in our discipline. We reconsider the classification of ergonomic activities in two large categories: correction and design, such as it has been defined by [12] and to which different authors and practitioners frequently refer. De Montmollin talked of *correction* and corrective ergonomics, when the ergonomist is called to solve actual problems of use, and of *prevention* and preventive ergonomics when the ergonomist is called to participate in the design of some artefact (e.g., a visual display). In our opinion, the terms prevention and preventive are not appropriate because they are too limitative for design and have a negative connotation; so we prefer the term design. In his analysis of the ergonomic practice, [22] talks of *curing* when the ergonomist intervenes in an existing situation for solving an actual problem of use, and of *envisioning design* when s/he intervenes to design a new situation, or envision new artefacts in context. Actually the categories defined by these two authors are similar. At one end, we have correction and at the other, put simply, we have design.

In this paper we propose to split the design activity into two categories: design and prospection, for the following reasons:

- To give full visibility to the part of the design activity that is concerned with the *creation* or *conception* of *future* things; in our opinion, this type of activity will grow significantly in the next years, and will have a major impact on our profession;
- To put emphasis on a new category of activity in the field of ergonomics: *prospection*, to which the literature on ergonomics for design did not pay much attention so far;
- To draw the attention of the ergonomics community on the needs for new approaches, models, methods, practices and tools in our profession to do prospection from the standpoint of ergonomics, be creative and innovate.

In the new classification, the role of corrective ergonomics remains unchanged and is clear: correct problems with existing situations (or with human work in general) so as to improve health, security, performance, ease of use and user experience. Inevitably, this activity will continue to be an important source of revenues for ergonomists. Note that this activity can be at the origin of creation and innovation but the priority is not innovation, the action is local, and the scope of correction remains generally limited to the specific project (e.g., a workstation, system, product or tool). The role of “ergonomics for design” looks the same as before and is clear: help to design good quality artefacts that are useful, secure, efficient, accessible, easy to learn and use, and able to create a positive user experience. What artefacts? Here lies the main difference between “ergonomics for design” and prospective ergonomics (PE). In the former the ergonomist’s work is greatly facilitated because there is a client and a demand (even though it often has to be redefined), the artefact to be designed is already identified, an initial solution may even have already been suggested to the ergonomist, the stakeholders are known (e.g., owner, clients, users), there is usually a project manager who orients and controls the work, and the timeframe and budget may already be outlined. In the latter, there may be none of these. Of course the design activity in “ergonomics for design” can be at the origin of creation and innovation but these are not request nor a priority, the action is usually local, and the scope of action remains generally limited to the specific project (e.g., design a Web site, a visual display, a cabin for passengers in an airplane). Finally the role of PE is to *anticipate* future user needs and activities in order to *create* and *design* new artefacts that will fulfil these needs and permit to accomplish these activities correctly. To do so, the ergonomist must be able to detect current needs and anticipate future ones (with the corresponding activities), and turn them into new artefacts. In the most difficult conditions, there is no client with a demand, the need is not defined yet, the artefact is not identified, the supporting technology is unknown, no project is proposed to the ergonomist, the stakeholders are unknown, the project initiator and manager is the ergonomist, and there is no timeframe nor budget yet. Table 1 shows how corrective ergonomics, ergonomics for design, and PE distinguish themselves from each other. Fortunately these extreme conditions are not the only ones for doing PE (otherwise it could be discouraging!). There are situations where one or several of the conditions are satisfied and we can still talk of PE because there are

unknown elements. Here is an example: A large company in Montreal recently contacted a team of ergonomists to reflect on the “Internet of things and new services for customers”. In this case there is a client with a demand, the artefact is identified, and

there is a project initiator and leader; however the need is unknown, the demand is very broad, there is no suggested solution, and the emphasis is clearly on innovation. PE is concerned by this type of project.

Table 1
Basic differences between Corrective ergonomics, Ergonomics for design, and Prospective Ergonomics

Categories of activities	There is a client with a demand	The needs to satisfy are known	The artefact is identified	A solution is suggested	Ergonomist is project initiator or leader	Emphasis on creation and innovation
Prospective ergonomics	-	-	-	-	+	+
Ergonomics for design	+	+	+	+ / -	-	+/-
Corrective ergonomics	+	+	+	+ / -	-	-

With PE, we push the boundaries and expand the field of ergonomics. We add prospection to ergonomists’ activities, and we explicitly put emphasis on creation and innovation. These activities will enlarge and enrich the roles and responsibilities of ergonomists, transform a part of their work and mission, and increase their influence on society. To succeed, we need new concepts, approaches, models, methods, tools, and collaboration with new disciplines. We also need to complete academic programs in ergonomics and develop new work practices. This calls for a debate about the future of our discipline.

To address these issues, we have structured the paper as follows: we define PE and prospective; we discuss the origin, the development and the timing of PE; we present several methods for PE; we analyze some user characteristics that should be taken into account in PE.

2. Definition of prospective ergonomics

As a part of ergonomics, PE inherits the scientific basis and the general mission of ergonomics. It is relevant to recall the definition of ergonomics and comment elements that shed light on PE. “*Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance*” [9]. First, in

PE, the “other elements of a system” do not comprise the artifact to be created since it does not exist yet. The challenge is to find a way to investigate the interaction among humans and the future artefact when it remains to be imagined. Second, the “design” activity should be taken in a broad sense and include the pre-activity of *conception*, like it is suggested in the “envisioning design” of van der Veer. Third, the criterion of “human well-being”, taken in a broad sense, includes health, security, comfort, well-being, personal development, satisfaction, and the global user experience; it is clearly human-centered and easily applied to PE. And the criterion of “overall system performance”, which depends on system qualities like usefulness, efficiency, security, usability, to name a few, suits PE very well. In this definition, there is no explicit reference to the future, nor to creation and innovation.

In a previous paper [19], we defined PE as « *the part of ergonomics that attempts to anticipate human needs and activities so as to create new artifacts that will be useful and provide a positive user experience* ». This definition deserves a few explanations. First it suggests a technology-pull approach since human needs and activities are the starting point, they precede, stimulate, and orient the development of technology, and hence the creation of new artefacts. This is no surprise in a discipline which always adopts a human-centered approach in its interventions, and where the core expertise of its professionals is clearly on the side of the human rather than on

the technology. Nevertheless the technology-push approach (where technology is available but has not found applications yet), however it is expected to be rare in PE, should not be excluded as long as the artefacts which come out bring a plus-value to users. The success of the two approaches depends on the ability of ergonomists to connect future human needs with technology ... or the opposite. Second, the activity of *anticipating human needs and activities* covers the short, middle, and long terms. It goes from the detection of current needs that could be satisfied right now to the anticipation of needs and activities that could appear years later. Third, the creation of new artefacts should be understood in a broad sense and also include significant improvements or transformations of existing artefacts. It is well known that the vast majority of artefacts available on the market are the results of improvement of previous versions instead of being new creations. PE is not an exception.

3. Definition of prospective

The word prospective in PE comes from *prospec-tion* and *perspective*, and refers to an established discipline. It is relevant to examine the characteristics of prospective and see how they apply to PE.

Prospective is a way of thinking which throws light on present action by looking at possible futures [6]. It consists in keeping a forward-looking eye on the threats and opportunities that an enterprise risks to face in the future. It is a process to help us to understand, plan, and manage upcoming changes. The term (in French: *prospective*) was proposed in the late fifties by French philosopher, manager and civil servant Gaston Berger to emphasize the importance of a future oriented attitude for facing upcoming changes. For him, the prospective attitude meant the following [7]:

- To look far away, as prospective is a long-term activity;
- To look breadthways, in order to examine interactions;
- To look in depth, to find the factors and trends that are really important;
- To take risks, because far horizons can make us change our long-term plans;
- To take care of the mankind, because prospective should fundamentally be concerned with implications for people.

Prospective activity is proactive. It recognizes that the future is uncertain, multiple, indeterminate, that it

cannot be conceived as a simple continuation of the past [6], and that it requires imagination. "To create the future one must first be capable of imagining it. Not predicting, not planning, not forecasting – imagining" (Ratcliffe, 2006). The prospective aims at reducing uncertainty as much as possible, and at helping to make decisions based as little as possible on hypothetical futures. Thus, its first aim is to illuminate the choices of the present in light of possible futures. It involves taking a view which is global, qualitative, voluntarist, and it is made of anticipation, action, and mobilization which are three inseparable elements of prospective. Some authors [18] talk of strategic prospective to emphasize its high-level and long-term perspective. Finally, it is neither forecasting, which is too greatly affected by quantification and extrapolation of trends, nor futurology which embraces all aspects of research into the future without specific reference to the criteria of globalism and will [6].

One key method for doing prospective, i.e. for the creation of "forward views" or "images of the future" [24], is the "imagineering" of scenarios. [18] explained how to use scenarios for creating network of people discussing about the future.

The characteristics of prospective apply to PE:

- PE looks far away but not only far away. Indeed it is interested in short-, middle-, and long-term activities. Prospective naturally evokes the long term but there is no reason to neglect the short and middle terms if they offer opportunities to create and innovate. It is also part of the mission of prospectivist ergonomists to try detecting current needs of people (not only future ones) and satisfy them with some artefacts.
- PE looks breadthways and examines interactions i) between people (e.g., the way they communicate, share information, help each other, solve problems, make decision, play together, have fun), ii) between people and artefacts, and ii) between different disciplines (e.g., industrial design, engineering, ergonomics, psychology, sociology, marketing) in order to unveil opportunities of collaboration and creation.
- PE looks in depth to find the factors and trends that really count. This is important especially for middle and long terms. It requires the capacity to collect and analyze large amount of information from different sources, the ability to perceive new phenomena and evaluate their importance, and the capacity to anticipate their consequences. The factors in play are classical: the people, their activities, the technology, and the context.

- PE takes risks since it deals with the future, and the future happens in a continuously evolving world with its complexity, uncertainty, contradictions, trends, etc. PE takes risks also because of financial investments in the development of artefacts that may turn to be unsuccessful on the market.
- PE aims at taking care of the mankind, and is fundamentally concerned with implications for people. This is no surprise from the offspring of ergonomics whose fundamental mission is to defend the user's point of view in the design of systems. In addition to being a source of revenues, the goal of creating new products and services is also to improve our quality of life.

4. Origin, development, and timing of PE

The first authors to talk of PE seem to be [10] [11]. They designated a part of ergonomics to deal with the future for middle and long terms.

In his book "*The design of future things*", [14] set the ground for PE by drawing attention of the ergonomics community (not only this one) on the importance of designing future things. In his paper, [22] analyzed the history and development of cognitive ergonomics and talked of a type of application he labelled *envisioning design* which clearly covers the design of future things. However there is no explicit mention to PE. We [19] have been active in PE by proposing a definition, by showing the potential of this new field for the full development of ergonomics, and by stressing the importance of elaborating a new corpus of knowledge for the training and practice.

PE is already a reality for a number of ergonomists, particularly those who come from design disciplines such as industrial design, engineering, computer science, and architecture. After an initial degree, professionals of these disciplines come to our field to learn about ergonomics/human factors and fortunately without having lost their abilities and interests in creation and design. Interestingly they often end up in a position (sometimes in the enterprise they founded) wherein they do projects that combine design and ergonomics, with a significant part of creation and innovation. PE suits them well.

It is no surprise to see the rise of PE in a discipline where we work closely with humans in all kinds of settings, where we put value on the implication of humans in our projects, where the validation of our work is often done through tests with users, and where there are always some artefacts in use.

Through these activities, we have the opportunity to talk to people, visit their environment (at work, at school, at home, in transports), observe them in context, see how they use and adapt to different artefacts, listen to their comments, claims and complaints, and be the witness of errors, difficulties, incidents, and accidents. With such rich data, we are in excellent position to think about solutions and new artefacts that would be helpful. What we propose here to ergonomists is to take advantage of their position where they can observe people and collect a lot of rich data, and become more knowledgeable in conception and design as well as in project management.

In the short history of cognitive ergonomics which is estimated to be about 30 years old, the timing of the appearance of PE corresponds, in our opinion, to the arrival of a new topic of interest that we call *Service design*. In the 80' and 90', the principal topic of interest of cognitive ergonomics was the usability of user interfaces. The focus was on how to design interactive systems that were efficient, accessible, and usable. In the years 2000, the principal topic of interest shifted from usability to User Experience with artefacts. The focus was not anymore on how to design usable systems, it was (and still is) on how to design interactive systems that can create a positive experience among users. This means designing systems which are not only efficient, accessible and usable, but which can also trigger positive emotions among users, support hedonism, and are aesthetic. Finally from now on, we predict that the principal topic of interest of the ergonomics community will shift from User Experience to Service design. The focus will not only be on how to create a positive experience among users, it will rather be on what products and services to offer to suit needs and competencies of the people.

The advent of PE does not occur out of context, it is rather the result of societal, political, and economical conditions. As proofs, we note the frequent discourse in the public space for promoting creation and innovation, the recognition of the crucial importance of R&D to innovate and remain competitive in the global economy, the creation of new training and research programs on Creativity, Innovation and Entrepreneurships in Universities, the encouragement to intrapreneurship in companies for stimulating creation and innovation among employees, and the support offered by governments to encourage technological innovation and entrepreneurships. PE appears in a favourable context.

Finally, considering the ever-increasing number of computer-based interactive systems we will be using in the future and the central role of technology in innovation, it is very likely that almost all PE projects will be based on computer technology.

5. Methods for prospective ergonomics

PE can rely on numerous data collection methods from human sciences to investigate human behaviour, and on different techniques and methods from the future studies literature for the rational discovering of possible futures [16] [8]. Several disciplines are concerned, including ergonomics, psychology, sociology, demography, management, economics, engineering. In the next paragraphs, we discuss four major characteristics of PE and different techniques and methods to act on them.

1) PE is *user-centered*. Like in ergonomics, the motto of PE could be “Know the user”. It is obvious that future users should be actively involved in PE activities. Several methods are available for fostering the implication of users all along the design process. For instance, to collect judgments from domain experts: interview, panels, Delphi method, case studies. To collect data from regular users or super users of artefacts: interview, field observation, automatic recording of actions, focus groups, questionnaire, surveys, walkthrough (a method for usability evaluation), usability tests, measures of user performance and satisfaction, claim and error analysis, etc.

2) PE investigates *users' activity in context*, and the *usage of artefacts in context*. As for activities, it aims at understanding what humans are trying to accomplish, what their goals and motivations are, what are the underlying needs, how much time they spend doing these activities, what difficulties or problems they encounter when doing these activities, how much satisfaction or dissatisfaction they have, etc. As for the usage of artefacts, the purpose is to discover what these artefacts are, what they are used for, how they are used, adapted, diverted, or transformed, how much effort is required to learn them and obtain a satisfying performance, what is the ecosystem of these artefacts and how they are connected to each other, what are their strengths and weaknesses, how much satisfaction or dissatisfaction they procure, etc. In our opinion, activity analysis and usage analysis are the key stones of PE. Two types of methods are available to carry out these analyses. For existing tasks: task/activity analysis where it is strongly rec-

ommended to follow an ethnomethodological approach which stresses the importance of observing people in real context. For tasks or activities that do not exist yet: scenario-based analysis. Each of these methods is supported by several data collection techniques: e.g., interview, observation, trace analysis, think aloud, protocol analysis, critical incident analysis, card sorting, communication analysis, critical decision analysis, etc.

3) PE is about *imagining the future*. To do so, PE can rely on different quantitative and qualitative foresight methods. For instance, [8] organized foresight methods in eight categories according to the goal to be achieved: i) Collect judgement from experts, ii) Forecast time series and other quantitative measures, iii) Understand the linkages between events, trends and actions, iv) Determine a course of action in the presence of uncertainty, v) Portray alternative plausible futures; vi) Reach an understanding of whether the future is improving, vii) Track changes and assumptions, and viii) Determine the stability of a system. For each of these categories, there are different methods either to collect data (e.g., Delphi), carry out analyses (e.g., Regression analysis, Trend impact analysis), do modeling (e.g., Futures wheel method : see [15], and run simulation (e.g., scenarios, simulation and gaming). In the human sciences, participatory methods with domain experts (e.g., the method “staffs of communities experts” from [4]), with super users of artefacts, and creative people promise to be excellent for anticipating changes, detecting trends, and generating new ideas. Furthermore methods like scenarios [20] and personas [3] have much to offer to PE. In the engineering field, the TRIZ method [1] should be of high interest for PE because it is a systematic approach to creative problem solving. The method exploits the fundamental mechanism of analogical reasoning to reuse the same principles of problem solving in design by bringing the problem to solve close to a model of canonical problem.

4) PE fosters *creativity* which is at the origin of innovation. Creativity can be defined as the individual or collective capacity to imagine a new concept, object, product, process, or solution. In typical working sessions, a group of people can produce a few dozens of ideas. Through the use of different techniques from psychology and sociology and the presentation of different contexts to people, *hypercreativity* can significantly increase the number of creative ideas produced by one person or a group of persons : it can go up to several hundred of ideas in a short period of time. For instance, [13]) showed in his thesis that in the context of prospective analysis of usage,

groups which were stimulated by specific techniques, could generate about 200 ideas in two hours. So PE will benefit from techniques of hypercreativity as well as from more traditional creative methods [23].

6. Users' characteristics and prospective ergonomics

In ergonomics, we put value on user implication in our projects. To optimize the contribution of users, it is important to know the users' strengths and weaknesses, and be aware of individual differences in order to contact the right users for the right thing, and have realistic expectations about their inputs to the design process. This is true and much more importantly in PE because we deal with the future and its complexity. In the next paragraph, we present five important characteristics of users that should be taken into account in PE.

1) The average user does not exist. The consequence is that we should identify the different groups of users which are concerned by a project and involve representatives of each of them in it. Between-group differences depend on several factors : age, sex, aptitudes, educational background, computer literacy, domain expertise, motor abilities, attitudes, etc. In PE, the groups of domain experts and super users deserve special attention. The former, because they know their « tasks » very well, they can exert their critical thinking and help to identify what could be improved and what is coming next. The latter because they like technology, they use products intensively, they spend time trying, analyzing and comparing their features, and they are always looking for novelties. They are in advance to the mass of users. Some authors [17] go even further : they identify cognitive styles and personality types of their users in order to identify leaders, innovators, conservatives, critical thinkers, ... and work differently with them. This looks like very promising in PE.

2) People can easily talk about their activities, and not so easily about their needs. They have difficulty to identify and define their needs because with the voice of the customer methodology, they do not know all their needs, they have needs they cannot articulate, the needs change over time, and they often confound needs and solutions that address these needs. [25] indicates that 90% of people polled during a recent webinar reported that they had never worked on a new product in their entire career in which all the customer's needs were known. He tries

to demonstrate that the voice of the customer methodology is the wrong tool to determine the customer needs and this creates the difficulties mentioned above. The focus should rather be on the « job » and on a fine analysis done by a specialist. His framework for understanding customer needs looks very interesting for PE.

(3) Users do not know what the technology can do for them. They do not know enough about the technology, especially if it is in development, and they have difficulty figuring out where and how it could serve them in their current activities or in the future without really using it. On the other hand, they are good at evaluating propositions of new artefacts when these are presented in a transparent way and in relation with their tasks and contexts.

4) Users cannot evaluate a system from a list of functionalities or specifications because it is too far from their reality, too abstract, not visual. They cannot really evaluate a system without using it. This is a challenge in PE because the system does not exist yet. As developers in PE, we should think visually and show the users as soon as possible how the system will look like and how it will be used.

5) Users are not designers. They are not trained to do design. They might be able to identify problems in a situation, for instance about a system, but this does not imply that they are able to find the best solution to solve it. Specialists are required to do that.

7. Conclusion

In this paper, we have proposed to introduce prospective into the field of ergonomics to envision the future and be prepared to design the situations of tomorrow. We presented several characteristics of PE and discussed their impacts on the profession. We hope that our reflections and our position in favour of PE will contribute to the advancement and evolution of ergonomics, and to the achievement of its full maturity.

Trying to anticipate the future is quite a challenge; ergonomists do not have a crystal ball and it is hard to believe *a priori* that they will be more successful than others. Nevertheless this is not a reason not trying to define it; they should look at the future for three reasons. First, ergonomists are in an ideal position to observe different categories of users interacting with different kinds of artefacts for doing a large variety of activities in all sorts of contexts. The close observation of success stories and usage problems,

with good and poor adaptations of artefacts, represents a rich source of ideas for imitating the good artefacts, improving the bad ones, and drawing lessons for innovation. Second, dealing with the future should have a strong positive impact of the ergonomist's abilities and attitudes in their work: they will develop a sharp sense of observation of people in their society (e.g., emerging needs, new habits), become fine observers of technology evolution and applications, be more inclined to imagine solutions to problems they encounter, be proactive and initiate projects, etc. Third, dealing with the future is an opportunity to participate actively into the definition of the world of tomorrow, to work on future high-level needs (e.g., learning, networking, development, self-realization), to have positive values drive the development of future artefacts, and to contribute to the improvement of our quality of life.

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