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Interdisciplinary Research and Practice in Ergonomics

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Introduction

The exchange between disciplines can range from informal exploration multidisciplinarity or to interdisciplinarity.
An interesting and somewhat unusual research study (Bollen *et al.*, 2009) supported by the analysis of nearly one billion user interactions recorded by the scholarly web sites of some of the most important publishers, highlights how exchanges between disciplines are common in scientific practice. These clickstream data trace an informal interdisciplinary network and tell us how the scientific community seeks out "boundary crossing" (Engeström *et al.*, 1995). These findings, however, convey a personal need to explore neighbouring areas, rather than a multidisciplinary collaboration.
In multidisciplinarity, many people work together on a common goal, while continuing to use theories, methods and tools from their own discipline. In a multidisciplinary approach, what is common is the overall outcome of the process, but the work practices and the individual actions are still proper to each discipline. In other words, people think differently, but act in an integrated way.
When speaking about interdisciplinarity, we go much further, as we deal with an approach that not only integrates the actions performed on the object, but also exploits a common vision of that object. In the case of cognitive science, for instance, the shared object is the mind as a computational system. In an interdisciplinary approach, traditionally independent disciplines such as philosophy and computer science, or disciplines that are already connected such as neurosciences and psychology, take a new common vision of the object, producing a cross-disciplinary epistemology.

Does ergonomics call for a multi- or an interdisciplinary approach?

Ergonomics has been variously defined, even if some of the definitions might suggest a kind of scientific impasse. Sometimes ergonomics has been defined as the study of men at work: however, not every study of men at work comes from ergonomics (Daniellou, 1996), nor is ergonomics uniquely the study of work.
According to the International Ergonomics Association, ergonomics is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system (IEA, available through http://www.iea.cc). Unfortunately, as Perrow suggests in his classic book on complex systems: "Interactiveness *per se* is not a useful concept. Almost any organisation of any size, whether public or private, will have many parts that interact once we look closely at them" (Perrow, 1984). To some extent, ecology could also be defined as the study of interactions.
We might draw a simple, but effective definition from the anthropologist Gregory Bateson. Reflecting on how often we interpret aspects of the human character like "aggressiveness", "dependency", or "courage" as personal inner traits, internal to the single person, Bateson reclassifies these characteristics into an interpersonal dimension, such as *patterns of interchange* (Bateson, 1979). That means, we are not aggressive, but we use that pattern to exchange with others.
This definition proves very appropriate when investigating the multi- or interdisciplinary approach of ergonomics. Ergonomics is the study of systems that need to develop a pattern of interchange to interact. In this case, the mutual adaptation does not come from evolution, it is not natural. It is an artefact built between two or more systems, including at least one human. Therefore, the purpose of research in ergonomics is how to design, and to implement, good patterns of interchange between artificial and human systems.
In this perspective, all the basic concepts of ergonomics embrace the motor, cognitive and emotional aspects of interaction. A classic example is the concept of *affordance* in the original formulation by Gibson: "I mean by it something that refers to both the environment and the animal [...] It implies the complementarity of the animal and the environment" (Gibson, 1979).
Taken from Gibson's studies on perception, *affordance* has proved a perfectly suitable concept for ergonomics, meaning something that does not pertain to the object, nor to the user, but to their relationship. As in Fig. 1, the branch of the tree does not offer great support to humans, but it does to a feline. On the other hand, a door lock can suggest a number of actions to humans.

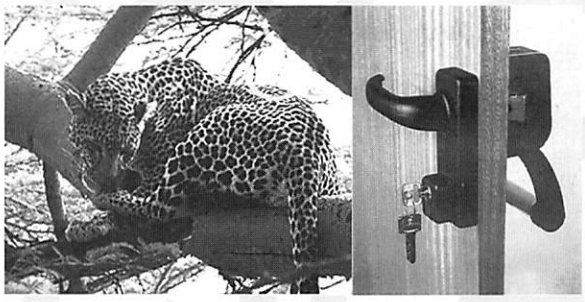

Fig.1. *Gibson's concept of affordance (1979)*

Patterns of interchange in a normative perspective we can delve into the multi- or interdisciplinary connotation of ergonomics by comparing two different patterns of interchange, the first from the foundation period and the second from present ergonomic research.
At the beginning, the simplest pattern of interchange adopted by 1950s ergonomists in designing the human-machine interaction was circular causality (Fig. 2). Pursuing the compatibility between the physical, perceptual, and cognitive human properties and the features of the

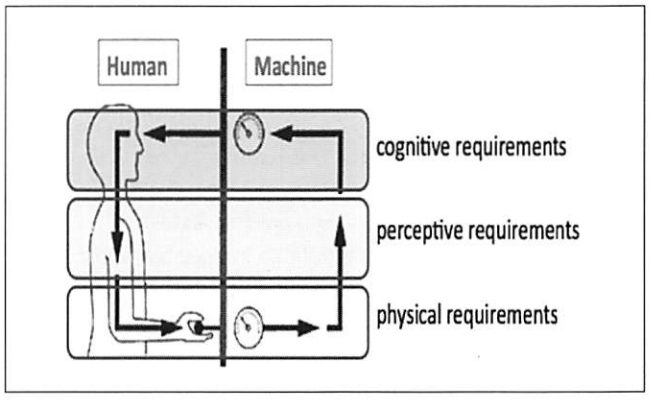

Fig.2. *Patterns of interchange in the normative approach to ergonomics.*

machine, the former are taken as the normative reference for designing the latter: two sets of requirements that ergonomists try to match, like mosaic tiles.
In this metaphor, ergonomics is a mosaic, a crossroad of disciplines: "The term 'mosaic' can indicate well enough the kind of multidisciplinary approach we have been satisfied with thus far: a juxtaposition of pieces, coexisting, more than actually cooperating [...] without breaking with their disciplines of origin. [...] One of the problems of growth for ergonomics is to define its boundaries with the disciplines close to it" (Sperandio, 1980). Within this approach, ergonomics is multidisciplinary: it is made up of people who think differently, and act together.
During the same years as Sperandio's analysis, the demarcation between ergonomics and the disciplines of origin was being consolidated internationally (Fig. 3). For at least ten years, from 1993 to 2003, the Italian Ergonomics Society worked full time to state in Italy what was already widely held abroad, the autonomy of ergonomics as a discipline.

Today, ergonomics has achieved its autonomy as an applied discipline in Italy (Di Nocera, 2004; Fubini, 2009), at least in

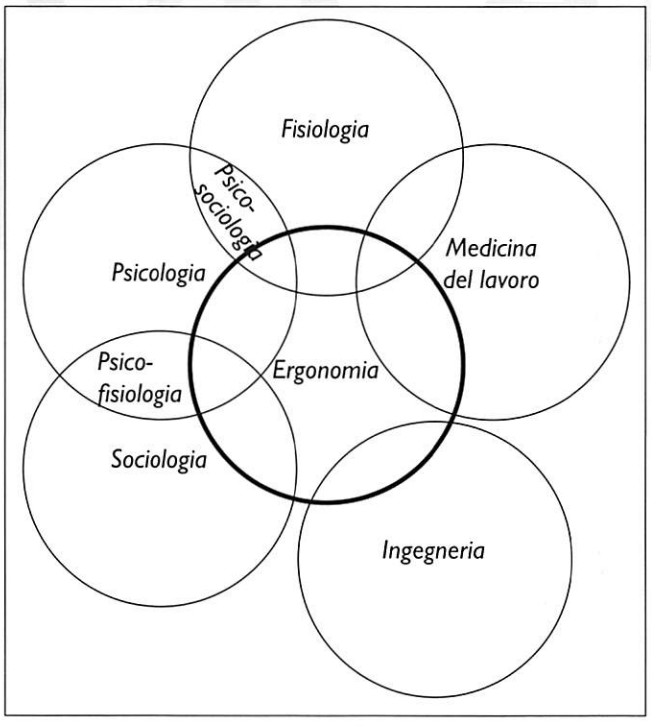

Fig.3. *The multidisciplinary approach in ergonomics (adapted from Sperandio, 1980).*

the more established physical and cognitive sectors.

Patterns of interchange in a descriptive perspective

The boundary line of organisational ergonomics is still largely to be defined. The core problem is how to investigate the patterns of interchange in organisations, where people collectively use the available resources in terms of environment, tools, rules and expertise to achieve the organisational targets.
While investigating the organisational artefact, we can abstract and look at the organisation as a new variable in addition to the others, merely triggering a different set of requirements. Maintaining a normative approach, we can speak of organisational load, as we do for physical or cognitive load, to be assigned to a specific expert. On the other hand we can state that the organisation is not one more factor to be added but the overall framework, the context of decisions and rules that enable all the interactions within the system.
Procedures, tools, environment, people, regularity of behavioural patterns: all these elements are the organisation in action, for the organisation only exists inside the work it organises, whereas the work does not exist outside of the organisation.
Let's look at an example of physical work in handling patients. The very act of handling imposes on the operator a different physical effort depending on the people available, the aids available, the time pressure and the obstructions

that are on the way. But all these aspects are organisational outcomes. So what actually determines the physical load is much more the organisation than the physical movement in itself.
A second example taken from an ergonomic intervention in a hospital: the problem of gloves that get broken or protection devices inappropriate for the task, which are therefore not being used or are used with discomfort.
The glove, the glasses: patterns of physical exchange that the physical ergonomist improves by redesigning the communication between the operational and the purchasing department, thus acting at an organisational level.
On the other hand, an example of cognitive ergonomics: the problem of errors in medicine, amply studied in the past two decades in terms of limits of attention, memory and general characteristics of cognitive processes. A major cause of the errors made in the preparation of drugs is represented by interruptions: relatives, patients, telephone calls, colleagues or emergencies. Again, essentially organisational causes.
However, the ergonomic solution can be environmental, as demonstrated by an interesting study conducted in Israel, where environmental and physical barriers were built as the most effective solution in preventing organisational interruptions (Straucher *et al.*, 2005).
Thus, a pattern of physical exchange can be addressed through an organisational intervention, and vice versa the organisational artefact can be addressed by adjusting physical and environmental interactions. If so, then ergonomics can only be interdisciplinary.

The methodology at the core of the interdisciplinary approach in ergonomics

We can use many research methods in applied ergonomics: experimental, clinical, ethnographic, to cite only some of the psychological methods. However, in any ergonomic sector we work, we cannot dispense with the interdisciplinary analysis of work activities.
This methodology provides the operative tool necessary to shift from a multidisciplinary to an interdisciplinary approach.
An old illustration taken from a classic ergonomics handbook of the late 1970s (Fig. 4) tells us that it is not sufficient to make the workbench match the anthropometric parameter, in order to fulfil the ergonomic principles. The ergonomic analysis considers which task is performed, by whom and in what context.
In fact, as pointed out by Vicente, "there is a rich tradition of descriptive studies in Europe going back at least 30 years. The Francophone ergonomics community, in particular, has placed great emphasis on phenomenological descriptions of current practices in naturalistic work settings" (Vicente, 1999).
In descriptive ergonomics, the activity analysis has always been a cross-sectional methodology, providing ergonomists with the possibility of integration and mutual acknowledgement.
We come to some concluding questions. The first is: if the vision is no longer multi- but rather interdisciplinary, is the heritage of normative ergonomics still useful? The answer is positive. We need it in the early stages of a process, when we design a new job or a new product, avoiding what is incompatible with the characteristics and limitations of the human operator. We need it in the final stages, when the descriptive analysis of work is achieved, and we design innovative solutions. Normative and descriptive are two different epistemological approaches (de Montmollin, 1996), but within the ergonomic intervention they rather seem different stages of the same process.
Looking into the near future, the second question is: is the concept of an "interdisciplinary discipline" actually sustainable? Some argue that interdisciplinarity is a temporary condition. When an area becomes a discipline, it is expected to lose its interdisciplinary status.
We can say that it could be different. At every stage of the analysis and intervention, all the problems are woven together: physical activity, mental processes, resource management, teamwork, communication. To address them we need different observational languages, upheld in their autonomy, but able to share their theoretical and methodological vision for an effective design.
This particular knowledge that is being developed within an interdisciplinary design, centred on humans and their physical, mental and emotional well-being, is difficult to find outside of ergonomics. Thus, I suggest we should never renounce this "interdisciplinary discipline".

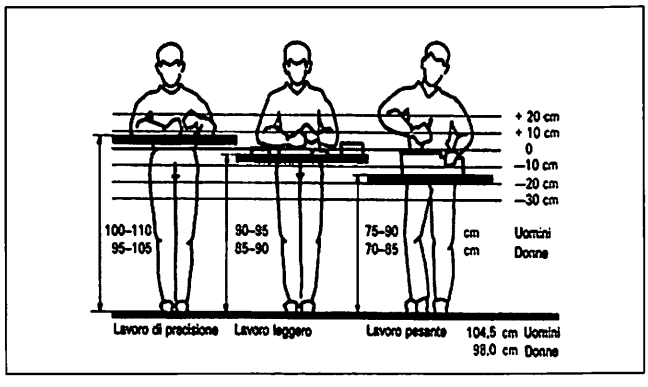

Fig. 4. *The ergonomic analysis of work activity (adapted from Grandjean, 1979).*

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