Applied Ergonomics 59 (2017) 558–569

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Reflecting on Jens Rasmussen's legacy (2) behind and beyond, a ‘constructivist turn’

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A R T I C L E I N F O

Article history:
Received 12 February 2015
Received in revised form
16 June 2015
Accepted 10 July 2015
Available online 21 November 2015

Keywords:
Rasmussen
Constructivism
Safety
Sociotechnical systems
Model

A B S T R A C T

This article is the second part of a study on the legacy of Jens Rasmussen. The first article, subtitled ‘A Strong Program for a Hard Problem’, looks back on his 30 years of scientific contribution, from 1969 to 2000. This second article explores and investigates some of the intellectual roots which influenced his thinking, using them as a basis to understand some limits and move forward. Indeed, historically oriented studies such as this one are not only tributes to researchers, but a way to differentiate and contrast our present situation with the past in order to integrate contemporary trends, be they theoretical or empirical, or oriented towards research and new models.

In the first section of this article, I offer a synthesis of the background covered in the previous article, but I use a tree here as a graphical complement. Branches of the tree show the many fruitful directions opened by Jens Rasmussen, directions which inspired many researchers. In the second part, I address what I believe to be behind this wealth of engineering legacy: cybernetics. I contend that cybernetics has had a profound influence on his thinking and provided him key principles for his inspiring and successful models. To develop the tree image, one might say that cybernetics is the trunk of the tree. Finally, in the third part, I take the opportunity to explore the relevance of extending and sensitising his program to constructivist discourses. After an introduction to this discourse, identifying four types of constructivisms (cognitive, social, epistemological and anthropological), I characterise this move as a ‘constructivist turn’.

1. Rasmussen's Legacy Tree

One is captivated, when looking back upon Jens Rasmussen's legacy, by his ability to convey complex topics ranging from cognition, accident, safety or sociotechnical systems in meaningful graphical representations. In the first article (Le Coze, 2015a), I have argued that this was one of his great and lasting contributions: powerful visual heuristics designed to grasp complex phenomena. They are taken for granted now, as part of our basic knowledge for different research areas (e.g. cognition, safety, accidents, errors, etc.), but were highly innovative at the time and have kept their intrinsic value ever since. If one uses a tree to account for his scientific work, the branches represent the many fruitful theoretical orientations shaped by these heuristics, which many authors adopted to pursue and establish new research directions (Fig. 1). Let's comment upon these branches without repeating at length what was already introduced and discussed in the previous article of the series.

2. The micro period (1970/1980)

Cognitive task (work) analysis (CTA/CWA) in relation to ecological interface design is a very good example to start with. It is located near the first branch of the tree on the left (represented here by ‘abstraction hierarchy’). CTA/CWA in ecological design is a methodology relying on a specific understanding of cognition (e.g. Vicente, 1999, Sheridan, 2002, Boy, 2010, Bennett & Flach, 2011, Naikar, 2013). Its purpose is to design appropriate physical and symbolic environments suitable to the ecological nature of cognitive processes within work constraints. The first branch is SRK (skill, rule, knowledge), indicating this specific model of cognition. This model, developed as an approach to cognition that is relevant for human machine interface designers, also provides a framework for a taxonomy of human errors. Reason (1990) is probably the most famous author in this area, referring indeed directly to the virtues

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http://dx.doi.org/10.1016/j.apergo.2015.07.013
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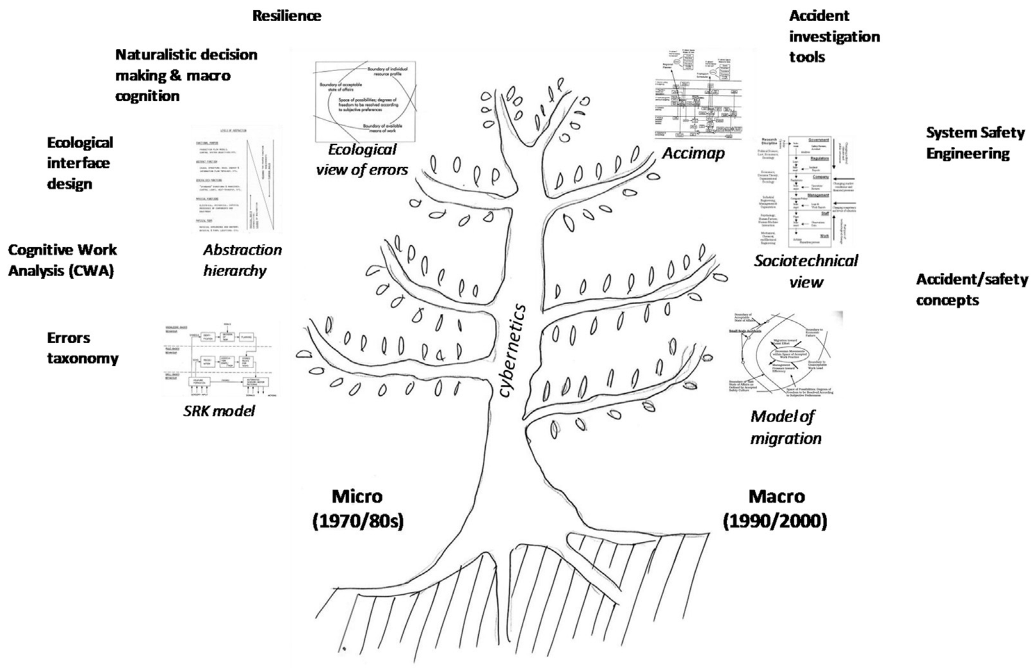

Fig. 1. Jens Rasmussen's legacy tree.

of SRK for this purpose. But the SRK model was rooted in an ecological approach to cognition, a view that in fact diverted research away from a taxonomic perspective of errors, towards a naturalistic one instead. Within this naturalistic view, the scientific and practical strategy consisting of categorising errors to eliminate them misses the fact that they are part of adaptive and learning cognitive processes (Amalberti, 1996). Errors are an intrinsic feature of individuals' experiences while exploring boundaries of acceptable practices. This idea developed into a more positive view of operators with the topic of resilience (Hollnagel, 1993, Hollnagel et al., 2006, Reason, 2008) but can also be found in the naturalistic decision making (NDM) research tradition (Klein, 1989, 1998, Lipshitz et al., 2001) or in macro-cognition. This constitutes a third branch (top left of the tree).

3. The macro period (1990/2000)

This micro view of cognition, rooted in an ecological orientation of psychology, was expanded, thanks to an analogy, into a macro view of safety/accident. This fourth branch, found on the right side of the tree, indicates a move towards a broader sociotechnical intention. Whereas the left branches concern micro layers of scientific investigation, the right ones represent attempts to frame issues at a wider or macro layer of conceptualisation. For Jens Rasmussen, the degree of freedom (1), self-organising and adaptive properties of individuals (2), and the notion of boundaries defining an envelope of viable/acceptable practices (3) combined fairly well for a move from a micro to a macro interpretation of safety/accident. The principle of "defence in depth fallacy" captured the idea of that accidents resulted from local practices of individuals under working constraints creating a migration beyond acceptable performance. The concept was subsequently applied and transformed by other authors into "practical drift" (Snook, 2000) and "resonance" (Hollnagel, 2004). By conceptualising accidents this way, it shaped early what has become known as a complexity perspective, with topics such as emergence, self-organisation and complex adaptive systems as key conceptual building blocks. I suggest that it delineates a specific interpretation of the "normal accident" thesis of Charles Perrow (Le Coze, 2015a, Fig. 7).

This appealing idea that one can translate micro into macro processes was also complemented by the so-called sociotechnical view. This is the fifth branch of the tree. In this view, a layered architecture symbolised by a vertical column brings together scientific disciplines associated with different layers (management, regulation, etc.) and open to the environment of the system (technological change, etc.). This is what I have defined as the "*strong program for a hard problem*", namely the ambition to address vertically the dynamic behaviour of sociotechnical systems (or, in the words of Jens Rasmussen, a functional instead of a structural perspective of safety). The "strong program" is the cross-disciplinary challenge both from a conceptual and empirical point of view.

The "hard problem" is the ability to both better understand and anticipate accidents through a cross-disciplinary functional analysis. This was as much a theoretical as an empirical challenge. But it is a challenge that authors have tackled in different ways, some with a strong engineering angle, relying for instance on system dynamics (e.g. Leveson, 2012), while others employed what I will call here a more "human factors" approach (e.g. Vicente, 2003). Finally, the last branch, at the top right of the tree, derives directly from the sociotechnical view by promoting an ACCIMAP vision of accidents, developed jointly with Inge Svedung (Rasmussen and Svedung, 2000), a proposition that was applied, for instance, by authors such as Hopkins (2000, 2012), and which is now part of multiple ways of approaching accidents (Underwood and Waterson, 2013).

At the end of this highly abridged tour of Jens Rasmussen's work, one must acknowledge the wealth of insights he provided to various authors, who in turn moved on to advance both practice and theory in many areas including cognitive engineering, the ecological view of cognition, investigating/representing accidents or modelling safety. An interesting comment can now be made, one that needs further development but is nevertheless worth mentioning. It concerns the power and lasting influence of graphical representations. If one compares Jens Rasmussen's legacy with