From Research to User-Centered Design

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ABSTRACT
We describe the approach taken by a UCD consultancy to radically renew its methods and techniques through the exploration of the gap between HCI theory and practice. The focus lies on models, theories and framework that are applicable to the domain of HCI-critical systems. The position taken here is that is it worth trying to bridge the gap, in a specific application domain, by trying out carefully selected promising theories in carefully selected product design projects.

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INTRODUCTION
Namahn is a Belgian user-centered design consultancy whose clients create products for use by consumers, in businesses and by technical specialists.

By 'products used by technical specialists' is meant products that are used process control, medical diagnosis, structural design, emergency response, cockpits, etc. They are often in the realm of safety-critical systems, where major loss of life or property is possible if errors are made.

In order to strengthen its offering targeted at these HCI-critical systems, it is necessary for Namahn to radically renew its methods and techniques. There is an abundance of academic and theoretical work that is applicable to the design of user interfaces for these systems because, indeed, it is exactly out of these application domains that Human Factors Engineering and Ergonomics, HCI's founding disciplines, originated.

However, the practical applicability of this large body of theory to current design practice is far from obvious and has become a topic of research for Namahn.

THE PRACTITIONER'S PERSPECTIVE
Obviously, the context in which HCI practitioners are interested in research is very different from the academic context. This context is characterized by a different type of

- Funding (private vs. mostly public)
- Planning horizon (short vs. long term)
- Liability (legal vs. epistemic)
- Justification (in terms of business case v. originality and scientific interest)

In such a context it is not surprising to observe that the complex methodologies proposed by researchers are difficult to adopt. They require a considerable amount of training and study to be understood and are very expensive to apply. As noted by Rogers (2004), this often leads to the dilution or oversimplification of core concepts, which then become susceptible to misinterpretation.

At Namahn part of our design manifesto is to view design as a rigorous discipline. As we focus on evidence-based design our activity is moving along the continuum from art, via craftsmanship, to science. This focus on a rigorous approach becomes even more important as we envisage a specialisation of our activities towards the niche of HCI-critical systems. For these systems, a good interface is not so much an added value (in terms of likeability and learnability of the system) but rather a basic requirement. HCI-critical systems are characterised by the following features:

- Complex (domain and task)
- Safety critical (failures may incur threats to human life, the environment, or may damage property or cause financial loss)
- Time critical (operators' efficiency is very important).

In this context, design rationale becomes a crucial notion. In order to tackle HCI-critical systems in a responsible way, we need to be able to motivate our design decisions rigorously; they need to be grounded in good science.

INTEGRATING RESEARCH INTO DESIGN PRACTICE
Namahn has always been interested in interacting with research and the research community. Important tools with this respect are: our library of professional books and

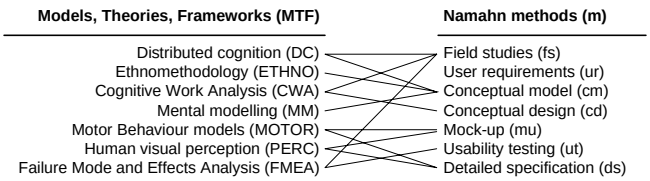

Figure 1: MTF/m mappings

journals, regular in house seminars by authorities in the different disciplines of HCI and Human Factors/Ergonomics, and a culture that invests in knowledge management. Although excellent relations are entertained with the academic world, very few projects are conducted jointly.

In a first phase of our research project, we have been examining in how far HCI models, theories and frameworks can contribute to enhance particular components of our existing in-house methodology. Figure 1 shows this mapping of Models, Theories and Frameworks (MTF) with Namahn methods (m)

The column on the left hand side consists of a list of models, theories and frameworks selected from (Carroll, 2003) (except FMEA). The column on the right side lists selected components from the Namahn methodology to which the MTFs are related as shown in the diagram. Each of the mappings was examined based on the corresponding contribution in (Carroll, 2003). This first analysis yielded interesting results: some MTFs were found to be already incorporated in our methodology (e.g. ethnomethodology, mental modelling), others didn't seem particularly relevant from a methodological point of view but still yielded interesting information for justifying design decisions (e.g. motor behaviour models and human visual perception). Still other MTFs seemed interesting as an approach either in general (FMEA) or in particular situations (e.g. CWA, distributed cognition). This approach is suitable for a company focusing on a broad range of products for which the likeability and learnability are the main requirements.

In a second phase, we started from the realisation that a tight focus on HCI-critical workstations was called for. In HCI-critical systems, the reliability and efficiency of the interaction with the software is a top requirement. Furthermore, where safety is involved, professional liability is to be taken into account. This requires a radical renewal of our approach, with an emphasis on design rationale. The practice of design rationale has pragmatic aspects (which representation to use, how to integrate it in the design process?) and content-related aspects (on the basis of which scientific findings can we motivate design decisions?). It is particularly in view of the latter aspect that Namahn is in need of research findings. We distinguish two types of justifications.

The first type of design decision justifications can be qualified as 'local', i.e. they concern one particular aspect of a design, e.g. the placement of widgets on a screen, or

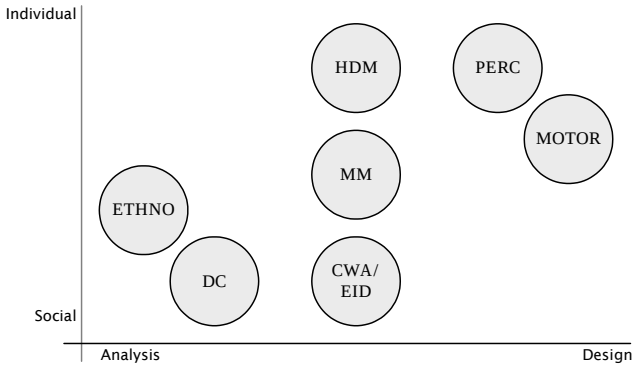

Figure 2: MTFs relevant to HCI-critical system

particular visual features (colour, size) of an interface element. These motivations can be found more or less easily in literature: e.g. motor behaviour models and human visual processing.

In other cases, design decisions need to be motivated based on information collected during activities taking place before the actual design, e.g. field studies or domain analyses. It could also be that features of the application justify the use of specialist theories and methods. For example, if the application requires coordinated efforts from various people, then the theory of distributed cognition is highly informative. Similarly, the Cognitive Work Analysis approach is specifically developed for complex socio-technical systems: applications where human operators control a complex physical process. In those cases, a justification of a design decision is more global as it requires the connection among different types of information arising along the trajectory of UCD.

Those MTFs that we found most significant are set out in a two-dimensional space in figure 2. The dimensions are (x) from pertinence to analysis to pertinence for design and (y) from a social to an individual perspective.

They are:

- Ethnomethodology (ETHNO)
- Distributed Cognition (DC)
- Human Decision Making, stress and error (HDM)
- Conceptual Models (MM)
- Cognitive Work Analysis/Ecological Interface Design (CWA/EID)
- Human visual perception (PERC)
- Motor behaviour models (MOTOR)

In order to validate the applicability of the selected local and global models, theories and frameworks to the design of HCI-critical products, we prospected the local (Belgian) market for companies that carry HCI-critical products in their portfolio, conforming to the following criteria, in decreasing order of importance:

- The application is **high consequence**: a failure of the system puts life, health, environment or property at

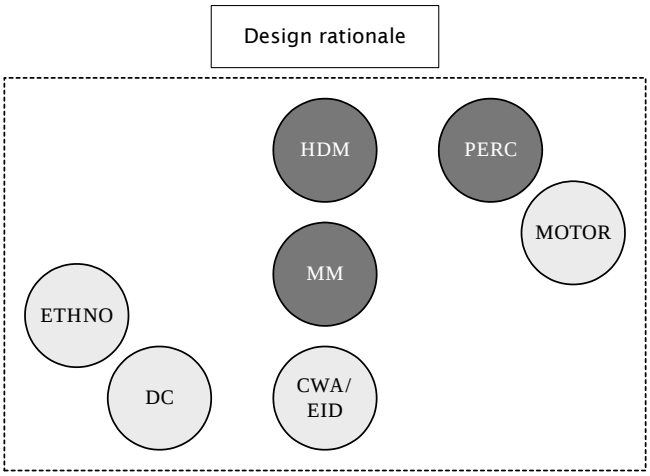

Figure 3: MTFs chosen for one particular case

risk. Typical applications are transportation monitoring and control, critical process control, diagnosis and test, emergency dispatching systems, trading workstations, surveying, and process/structural design.

- The **user interface** is an important component of the system: it is critical rather than accessory to its proper functioning. The user interface's contribution to reliability and efficiency is more important than its contribution to likeability or learnability.
- Users are **professional operators** with considerable training in the domain.
- The product release is scheduled on a **3-6 year horizon**.

We have found five companies willing to participate in this empirical validation. They create products in medical diagnosis, map surveys, satellite communications and process control. In return for at least one man-month of their R&D staff and access to their user base, they receive insights that could inform their future products.

For each case, we chose a number of MTFs that appear promising in terms of applicability to the case, practicality and soundness, as in figure 3, for example:

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