Metaphors, Conceptual Models and Evolutionary Epistemology

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Abstract. Starting from views on traditional metaphor and mental/conceptual model theory this paper describes the possible influence of the »evolutionary epistemology« (EE) theory to the HCI theory base. This theory is particularly important to HCI especially because of its culture independence on the proposed basis and its coverage of unconscious processes. The first had been a long struggle and still is. For the second area it holds true, that the vast majority of studies and models are dealing with rational part of cognition. This rational part, as is shown by EE rests on the concepts of »ratiomorphus apparatus« and it even cannot be freed from this pre-assumptions given in that apparatus.
Meta-communication via training, manuals or even short explanations is getting more rare. Systems are used as is. Which makes it important to get system images »self explanatory at first sight«. Furthermore systems are turning more and more towards multi-media systems, which indeed calls for integration of the different senses. It seems that graphical user interfaces are well studied but senses apart from the visual are missing. Sound and haptics are often designed carefully but sometimes separately from the rest of the design. Not to mention olfactory.

1. INTRODUCTION

At least since the advent of the World Wide Web a decrease of "meta-communication" about human-machine interfaces can be observed. No documentation, no training is offered, available or even possible. The interface »per se« stands alone for itself. These changes should be accounted for and new theoretical ground should be opened. It is important to have culture independent approaches to reach user interfaces for all. One could be found in human history – in evolution. More than 3 million years of history and evolution of our cognitive apparatus that can be traced directly to our species gives a solid starting point.
Up to now much too less attention has been spent on the unconscious part of our ideation. Which has its natural negative effects on theory building in HCI. The effect of the theory introduced here can be manifold. Central effects are expected to be found in the way we look at cognition and therefore in the area of mental models as well as the connected theory of metaphors which form the core components to the user-interface [Marcus 02a]. Since these terms are sometimes used with divergent meanings a clarification of common understanding on these elements should be established first.

2. METHAPHORS

Metaphors has a long history in HCI, and their usefulness, their future and sometimes their characteristic are still subject to debates. Perhaps currently even more while systems are changing and computers mutate to e.g. appliances, distributed ubiquitous computing, virtual realities, and so on.
Different approaches have been made to categorize metaphors (cf. [Lakoff 80], [Mac Cormac 85], [Indurkhya 94], [Neale 97], [Marcus 02b]…) and important discussions were undertaken with respect to the distinction of metaphor, analogy, and simile (cf. [Halasz 81], [Holyoak 95], [Laurel 93], [Nelson 99], [Tourangeau 82], [Carroll 85], [Collins 95]…)

What most of the times is left out from the discussion is that the computer science discipline is full of metaphors [Johnson 94]. Since the user-interface of a system is still part of the whole software-system it is natural to find metaphors in the interface.
Lakoff on the other hand says that metaphors cannot only be found in literature and poetry but is moreover a concept of everyday language in the form of »everyday metaphors«. (see [Lakoff 80], [Lakoff 89], [Lakoff 93]). This is especially true as soon as one moves away from concrete physical experience and starts talking about abstractions or emotions. Then metaphorical understanding is the norm [Lakoff 93].
The bridge back to human interface design can be found in various papers and books (e.g. [Smyth 95], [Marcus 02a], [Marcus 02b]). In computer operating systems, metaphors substitute for collections or individual elements and help users understand, remember and enjoy the entities and relationships of computer-based communication systems, says Aaron Marcus [Marcus 02b].
In HCI it can be stated that in its essence the previous description seems to be a bit more functional than things might be seen in poetry and literature (The description above is surely not a singularity of metaphors "functionality" in HCI (e.g. [Neale 97])). In these disciplines the term is (sometimes namely) understood as a »tertium comperationis«. Which describes the use of "golden" instead of "admirable", "gazelle-like" instead of "comely" [Riedl 00] p.133 (cf. [Lakoff 80], [Lakoff 89]).
These things might be of great cultural value, but what is needed in user interfaces design is more like a functional analogy. But this is a structural position not a naming debate. Therefore the denomination »metaphor« will be kept as a term to avoid confusion with the discussion on analogy. The term »functional-analogy« in the notion of EE will be more clearly defined in the third section and should not be confused with the solely "analogy" term mentioned here.

3. CONCEPTUAL MODELS

The second important concept in user interface is the conceptual model. In this paper conceptual model is understood in the form Norman [Norman 83] has defined it. He distinguished between three elements that work together in the interface. Two mental models: the user's model, the designer's model and finally the systems image (see Figure 1). One of the paramount interests next to usability testing of HCI is to improve the design of interfaces in first place. Therefore it is a proven good idea to use prescriptive mental models, so called conceptual models, throughout the design (cf. [Norman 83][Johnson 02]). The design goal is to reach as much as possible congruence of all the mental models. The big problem nowadays is that there is no possibility for any meta-communication anymore. Documentation is most of the times not read or unavailable (e.g. with web) nor training or debate is offered or consumed. The only way to communicate the designer's model to the user is via the system image (to which I would include the documentation part).

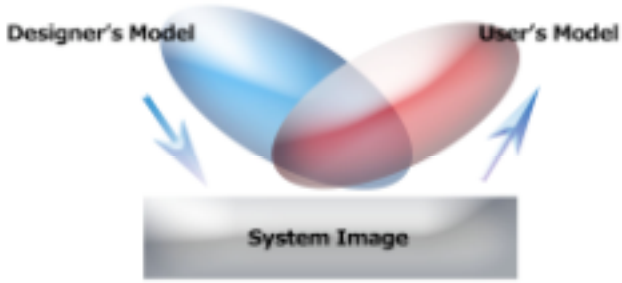

Figure 1: Designer's model, user's model and the mediating system image. The user's model will never be exact the same as the designer's model. There are extensions and shortfalls. (cf. [Norman 86] with additions)

The system image is built on the basis of the conceptual model that is developed during the design phase. Since the conceptual model is synthetic, it must be built up piecemeal; and the pieces are (though not exclusively) conveyed by metaphor. [Halasz 81] p.386 (cf. [Collins 95]).
The user interacting with the system has to bridge the gulf of execution and evaluation, according to Norman [Norman 86], in seven stages. While this is a proven supportive and explanatory model in general. This paper advocates an extended incorporation of the unconscious or sub-conscious, which cannot be rationalized [Collins 95] p.180-181, into the models on the basis of EE. Therefore it is suggested to change the metaphor from gulfs to mountains and from bridges to tunnels (see Figure 2).

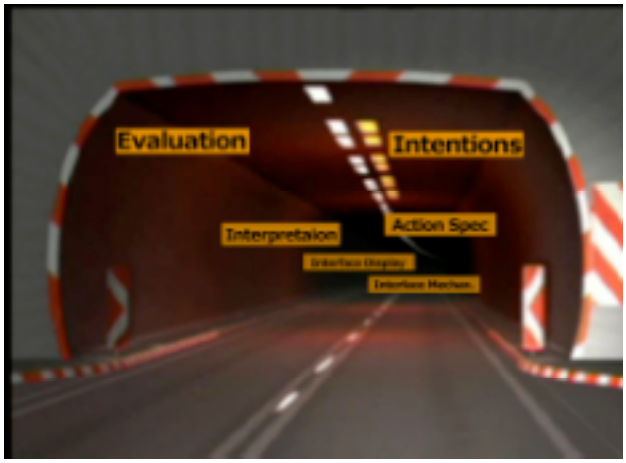

Figure 2: Tunneling the mountains of Execution and Evaluation. According to Norman [Norman 86] but stressing the point of unconsciousness.

With mountains you cannot see fare and wide as it is the case with gulfs. Furthermore in a tunnel you have to trust in that there is another side; it is dark; and it cannot be easily inspected from the outside. Adopting such a metaphor would also make a strong argument to incorporate unconscious areas into conceptual models.
This addition to the "traditional" meta-model leads also to the extension of the evaluation-criteria-set to metaphors for the system-image of the user interface. Additional qualities could be added to the conception of mental models and these qualities will be even cultural independent.

3. EVOLUTIONARY EPISTEMOLOGY

The basis for the following insights are the »evolutionary epistemology« (EE) developed and stated by Lorenz [Lorenz 87] and Riedl [Riedl 84]. It shows, empirically supported, that the preconditions of human reason are ontogenetically an »a priori« (comparable toe the Kantian categories) to the individual and that they are derived phylogenetically from, and adapted to, that form of reality which we experience as the phenomenal world.

It states a system, called the »ratiomorphus apparatus« by Brunswik [Brunswik 95], of »innate forms of ideation« which allows our anticipation of space, time, comparability, causality, finality and also a from of subjective probability [Riedl 84]. Although this system is very analogous to our rational behavior »ratiomorphus« doesn't have anything to do with conscious reason [Lorenz 87].

The »ratiomorphus apparatus« is assumed to be a phylogenetic preparation and precondition of human ideation. Each of those ideations can be understood as 'inborn teaching mechanisms' or as 'inborn hypotheses', which enable living beings to cope with some basic phenomena of the mesocosmos [Mohr 81] to which they have adapted. Riedl [Riedl 84] has identified four of these hypotheses. Each of which builds on the previous one. The first and fundamental hypothesis is the »hypothesis of apparent truth«.

3.1. Hypothesis of Apparent Truth

The expectation in this hypothesis rests on the following layers of preconditions: the assumption that certain events can be observed again with a certain probability which leads to the assumption of reoccurrence of arrangements in this world and with that to the assumption of a apparent real world. The hypothesis of apparent truth states the expectation that some of the experiences can be predicted as probable under suitable conditions and that they can be confirmed by their reoccurrence [Riedl 84].

This is contradictory to what logic and statistics tells us: No event gets more likely by its repetition. But given the layering of the preconditions in these hypotheses it also makes sense (at least common-sense) and has proven to be correct [Riedl 92].

This hypothesis is fundamental since correct predictions are of life-sustaining importance to all living beings. It produces prejudices or judgments in advance or anticipations of phenomena occurring in the future. It deals with probabilities, and guides the propensity of the organism to make predictions within different degrees of confidence, which ranges form complete uncertainty ('don't know') to certainty.

Furthermore it gives a fundamental advice to human interface design: consistency. It is not by chance, that for example Shneiderman [Shneiderman 90] calls for consistency in almost every chapter of his book. One thing that the »hypothesis of apparent truth« teaches us is that without any consistency there is nothing to recognize. The other way round: we do expect repetition. This is more than common view to consistency is. In common consistency is seen as a facilitator to learning. Though this is true, the fundamental concept addressed here has to be considered. Especially the vice versa implication seems to be of great value to consider as one can see as a result of the next hypothesis. Furthermore consistency has to be considered as really fundamental. Within our »ratiomorphic apparatus« it is so fundamental that if it is missed all the rest collapses.

3.2. Hypothesis of the Comparable

The expectation in the second hypothesis is that it is possible to balanced out the dissimilarity in the perception of things and that similar things, although they are obviously not the same, are comparable even in properties so far not perceived. The expectation is that similarity gives foresight to further similarities [Riedl 84][Riedl 87]. In other words one may add the expected to the perceived.

These expectations create structure. They are pre-judgments and pre-structures to the perception, which indeed have again life-sustaining importance. This can be shown by simple, even classical examples. It does make sense not to think that a distant lion is a funny ant-sized lion. It does make sense not to expect the tail of a loin to be without any loin and it does make sense not to have a debate on that but a "ready-made" answer.

The downside is important for the user interface design. This is exactly why pictures of wire-cubes, by wax-flowers, even movies and so on fools us. For our ideation it doesn't make any difference if the reality is human-made or not. There is only one reality says Gibson [Gibson 77].

Moreover we do constantly look for structure. If there isn't one, we structure it. This effect can easily be seen with star constellations (see Figure 3). There isn't any great or little bear or dragon, twin etc. Now, this implies that user interfaces should make structure explicit. If no structure is perceivable it will be constructed from what is believed to be there.

Figure 3: Little Bear as seen in starry night and with making connecting lines explicit.

Furthermore especially in language we find the making of the similar out of the dissimilar. This is nothing less than a metaphor. How else could we communicate? No doubt that human beings are not only fundamentally toolmakers [Levi-Strauss 00] but also metaphor-makers.

This hypothesis deals essentially with the properties of objects. The analysis and cataloging of properties of objects in the to-be-designed-system-image would be paramount and there is so fare no such catalog available. Especially for multi-media systems properties in respect to all our senses have to be examined. Overall analysis would unveil sets of discriminatory properties like the ones have been found for living systems in biology.

Basically we can observe properties at the same time or successively. These two different ways are ratiomorphic and also consciously computed differently. The first will appear as gestalt-experience, the second as cause-experience.

3.3. Hypothesis of the Causality

The expectation in the third hypothesis is that from similar events or states similar successive events or states will be foreseeable. Furthermore, that from a field of similarities, that is a

defined set of events or states, a successive defined set of events or states will be foreseeable also. In other words, the expectation is that similar events or states have the same cause and will have the same effect [Riedl 84].
From this hypothesis three different cause-relations can be identified: »chance-analogy«, »functional-analogy«, and »homology and typus«. »Chance-analogy« means that the cause of the analogy cannot be identified. For example the obviously comparable shape of the blossom of a bellflower does not share further internal or external causes with the bell.
If the cause can be found outside of the object, then Riedl [Riedl 84] calls this »functional-analogy«. If it is inside of the object it will be called »homology and typus«.
This analysis has impact on metaphor. If there isn't any reason for the similarity then it will be treated like an analogy by chance. Less (in most of the cases nothing) can be learned from this kind of analogy. The contrary is true for the other two types. Therefore it could be concluded that the type of »functional-analogy« should be avoided in the user interface. Examining an interface metaphor in relation to that respect could give a good clue on its performance.

3.4. Hypothesis of Purpose

Finally, the expectation in the fourth and last hypothesis is that functions in similar systems may be understood as sub-functions of the same higher system. In other words, the like structures correspond to or satisfy the same purpose. This means to infer from same sub-functions to the same higher functions.
If we have seen e.g. one pipe, all pipes raise the expectation of a sub-function of conducting in some super-system. The assumption behind this is that everything serves its purpose in a big hierarchy of sub- and super-systems.
Also here this assumption is always present and this brings with it that even if there is objectively no direct connection such purpose interpretation takes place. This results in »magical thinking« and this is a recognized problem in user-machine interaction.
In the context of user interface design the hypothesis means: if objects have the same structure and cause they are perceived as if they would have the same purpose.
This hypothesis must have been developed on a higher stage of evolution than the others before. To derive such a hypothesis a notion of the »I« is a necessity and with this hypothesis the »ratiomorphus apparatus« is touching the conscious thought.

4. CONCLUSION

Incorporating the unconscious part of mental models, described in terms of EE, into designers conceptual model is recommended. This would be worthwhile doing, since (a) some relevant aspects to the design could already be shown. Among these aspects are consistency as a basis for perception in general; structure is omnipresent even there is no objective one; sorting out different causes and avoid »analogy-by-chance« and the relation to this and »magical thinking«. Then (b) on the level of the »ratiomorphus apparatus« the universality and cultural independence is naturally given, since this apparatus developed long before the movement of humans »out-of-Africa«. Following »out-of-Africa« theories [Zhivotovsky 03] to describe the descent of all people and the fact that this »ratiomorphus apparatus« did not change since gives the basis for this position.
This paper focuses especially on designer's conceptual models and metaphor conception, since some of the biggest effects in adopting this theory to HCI can be expected there. The

research on the incorporation of EE into the HCI is ongoing and so some of the results are currently preliminary. But what already had be shown is that EE brings some additional insights to the theory basis of HCI.
Further effort will be placed in theory-based guidance to metaphors and conceptual models. In particular the effects of this theory to concepts like gestalts-perception, affordances [Norman 99][Gibson 77], navigational aspects like mapping of network-based environments to a hierarchical ideation, etc.
Analysis of differentiating property sets of image system objects has to be undertaken to lead to practical design guidance on the systems image level. Studies on the basis of eye-tracking to determine these differentiating property sets are on the way among others.
The effect of the differentiation between functional-analogy and homology and typus to the conceptual model, the selection of metaphors, and finally to the user interface has to be evaluated in more detail. A formal analysis has to be done to show the effects.

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