The importance of users' mental models for developing usable human-machine interfaces

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The importance of users' mental models for developing usable human-machine interfaces

Radka Nacheva

Abstract: One of the most important factors for success of the computer systems *is their usable interfaces. This means that target users must work with the systems intuitively, efficient and effectively. With regard to this designers have to develop usable human-machine interfaces which are naturally connected with users' mental models and consequently to give them a chance for easier and satisfactory work. The purpose of this report is to emphasize the importance of studying the users' mental models to developing usable human-machine interfaces, and also to propose a new kind of mental model diagramming – hierarchical chart based on the results of the brainstorming session.*

Key words: mental models' importance, usability, human-machine interface, hierarchical mental model diagram.

INTRODUCTION

Mental models were known to cognitologists since 1943 by Kenneth Clarke's book "Nature of explanation." They could be defined as psychological images / descriptions of real, imaginary or hypothetical situations that individuals form knowingly or unwittingly by their experiences and guiding humans' thoughts and actions. Indi Young explains that "mental models give you a deep understanding of people's motivations and thought-processes, along with the emotional and philosophical landscape in which they are operating"[3]. On the one hand, the reality is perceived trough models, causal relationships for specific events and actions are explained and respectively expectations are formed for the implementation of certain results. Mental models are basis for building the internal stability in a constantly changing world. On the other hand, preclude adequate understanding of facts and ideas that challenge or defy these deep beliefs. Each individual has different models for the same concept or object. Their study is related to the penetration into the human consciousness in terms of making decisions and building behavior in different environments, based on accumulated knowledge and the specifics of their perceptions.

Along these lines there are many studies which are used in a number of other areas, including human-technology interaction, particularly in usability evaluation of the user interfaces. Cognitive scientists are engaged in research on the users' mental models to help creating usable human-machine interfaces, i.e. those that are in accordance with the prior individuals' picture of the technology's interface and satisfy the posteriors after the usage of the technology. In connection with this, **the purpose of the present study** is to emphasize the importance of studying the users' mental models to developing usable human-machine interfaces, and also to propose a new kind of mental model diagramming – hierarchical chart based on the results of the brainstorming session.

MAIN CHARACTERISTICS OF USERS' MENTAL MODELS

Viewed from the perspective of human-technology interaction mental models might be defined as „based on belief, not facts: that is, it's a model of what users know (or think they know) about a system"[4] such as ours and "about what is going on inside an external system".[5] This means that we must distinguish between the mental models of a system and knowledge about how to work with it. Belief in something is not necessarily supported by evidence. Therefore, faith is not knowledge.

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[3] Young, I., Mental Models: Aligning Design Strategy with Human Behavior. Rosenfeld Media, 2008, p. 3
[4] Nielsen, J., Mental Models: <http://www.nngroup.com/articles/mental-models/> (14.07.2015)
[5] Olson, G., Some thought about mental models in human interactions with computing systems: Reflections on the Breckenridge workshop. Mental Models and User-Centered Design. ARI Research Note 90-82. United States Army Research Institute for the Behavioral and Social Sciences, July 1990, p. 55

The definition of Kieras & Bovair specifies mental models as "some kind of understanding of how the device works in terms of its internal structure and processes"[6] Another definition tells us that they are "knowledge of how the system works, what its components are, how they are related, what the internal processes are, and how they affect the components. It is this conceptualization that allows the user not only to construct actions for novel tasks but also to explain why a particular action produces the result is does"[7].

Based on these definitions, we could conclude that the mental models of users are connected to their expectations (combination of prior knowledge - theoretical and practical, and beliefs) for a system before using it for the first time. But what will happen after the implementation of a genuine work with the system? Then the reality and expectations will cross and the result will be the creation of new mental models or upgrade existing ones. It will be formed a posterior mental model for the technology's interface and similar to it, which will work in the future. The last is associated with one of the strongest positive aspects of the application of mental models, namely their use for predicting the performance of the functionality of a technology. In regard to this, the research of users' mental models is an essential part of testing the usability of software products - based on them it should be established a design concept that will fully meet the real needs of the target audience.

It is important to point out that people build individual mental models for each object, including technology. Therefore, it is appropriate to be called "*target mental models*".

Based on the foregoing and on some key characteristics of mental models[8], we could deduce their importance to developing usable human-machine interfaces:

- the research of mental models will help shaping a more precise and clear ideas about the ways in which the representatives of the target audience think of the technology;
- developing of human-machine interfaces that naturally coincide with the perceptions of users contributes to greater satisfaction and fast work, easier learning of the proposed technology's functionality and easier recovery from errors[9];
- timely study of the mental models of the representatives of the target audience in developing the new technology helps reduce the so-called „design gap"[10] and even before the technology reached the market;
- due to rapid development of information technologies and their active use in daily life suggests that users of these technologies improve or constantly changing their mental models, which means that they must be studied in the development of new software, featuring a completely different concept;
- the development of a new kind of software according to users' mental models highlights the extent to which it might be different and therefore reserves the already known features [11].

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[6] Kieras, D.; Bovair, S.. The Role of a Mental Model in Learning to Operate a Device. Cognitive Science Volume 8, Issue 3, July 1984, p. 255

[7] National Research Council. Mental Models in Human-Computer Interaction: Research Issues About What the User of Software Knows. Washington, DC: The National Academies Press, 1987, p. 6

[8] McDaniel, S., What's Your Idea of a Mental Model? <http://boxesandarrows.com/whats-your-idea-of-a-mental-model/> (14.07.2015)

[9] In accordance with the five quality components of usability defined by Jacob Nielsen: Learnability, Efficiency, Memorability, Errors and Satisfaction (Nielsen, 2012)

[10] The discrepancy between knowledge users and decision about the user interface based on it. (Wood, 1998)

[11] It is connected with the creation of some users' the confidence that they can perform certain actions, i.e. confidence in their own skills and knowledge. And even more – the safety about standards for developing a specific technology are met. For example, users expect when they press the back arrow button it will be performed Undo action.

HOW TO CAPTURE USERS' MENTAL MODELS ABOUT HUMAN-MACHINE INTERFACE

There are different methods aimed at exploring usability. In general, we could divide them into methods with and without the participation of the target audience. To study the mental models of users, there is a need to be applied methods of the first group. For example, Thinking-aloud protocol, Question-asking protocol, Coaching method, Field observation, Interviews, Focus groups, Contextual inquiry and other, in which users could express their own views on the technology's interface.

For the purposes of this study we have narrowed the circle of the methods, aimed at holding brainstorming sessions. They are a proven way to generate ideas based on users' perception of the purpose and functionality of a given technology. The session could play the role of control meeting of joining ideas. One of the proven effective types is the nominal group technique. Its most common use is to generate a list of ideas that are recorded anonymously by individual participants in the session. We suggest a possible variation: ideas can vote on a scale of evaluation, where 1 corresponds to "highly inappropriate idea" and 10 to "innovative idea". Reached the highest score is again subjected to discussion. The ultimate aim of this session is generating the maximum number of useful ideas for the technological project to improve the usability of the interface.

In practice, the organization of the sessions' results is by using diagrams of similarity or mind maps. They could be inefficient for projects involving many ideas as the location of the first type diagrams is only horizontally. This makes understanding them more difficult and requiring considerable volume of space. In terms of the mind maps we point to as excessive complexity flaw imaging in cards with multiple branches. Therefore, we believe it is appropriate to use another chart type, which must be characterized by ease of perception and compact display without crossing links between elements of the chart or a grid visualization. As a suitable alternative, we would like to offer pyramid display, similar to Maslow pyramid representing the hierarchy of human needs which is used in management theories. To form a hierarchical representation of mental models we integrate only the idea of using such a diagram with color distinction and categorization, but not with the terminology proposed in motivational theory of Maslow. The model represent ideas generated during brainstorming session.
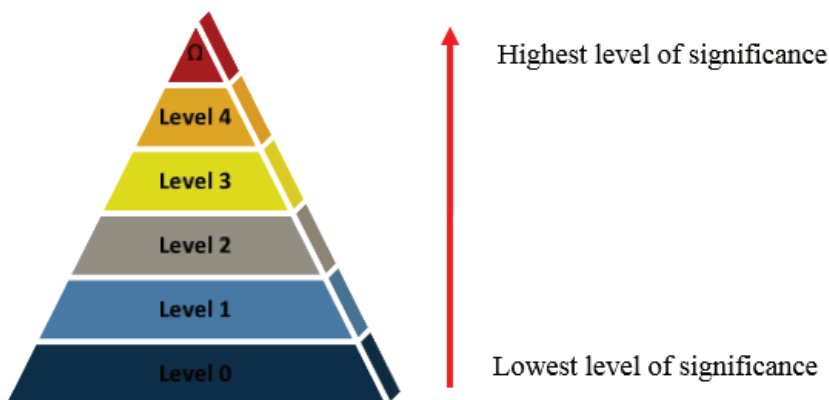

Figure. 1. Hierarchical mental model diagram

The model presented by Figure 1 offers conceptual gradation of 6 levels with different color distinction for each level. Levels 0 and 1, depicted with colors of the cold range, which should include ideas that are not critical to the success of the project. Level 2

is a critical minimum level, which is recommended to be implemented in order to lay solid foundation of the project. The next three levels represent ideas that are essential to the full realization of the concept of interface, i.e. they are **mandatory**. In the top of the pyramid (Level 5 or **Level Omega**) there are available innovative ideas that ensure the success of the technological project. This means that the pursuit of usability specialists who conduct the brainstorming session should be reach Omega level with as many as possible innovative ideas.

At each level of the pyramid we offer to get set weights of words to show the extent of supporting a given idea by the people who participated in the sessions. Weights are defined simply - the rating which received the idea of the brainstorming session. It is recommended that ideas with a higher rating to appear in a larger font to stand out against the others. The severity of the ideas generated by users determine the step which formed their mental model.

We can conclude that the mental models, which will be formed, are actually concepts of users about the specific technology - software or hardware.

CONCLUSION

The studying of users' mental models has its undeniable positives in terms of developing a usable human-machine interfaces, the most significant of which is natural ways for the user of the technology to perform specific tasks. This means that the target audience has to get to know in order to succeed in it.

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