Chapter 2.7
Guidance in the Interface:
Effects of Externalizing Information During Problem Solving

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ABSTRACT

How can we design technology that suits human cognitive needs? In this chapter, we review research on the effects of externalizing information on the interface versus requiring people to internalize it. We discuss the advantages and disadvantages of externalizing information. Further, we discuss some of our own research investigating how externalizing or not externalizing information in program interfaces influences problem-solving performance. In general, externalization provides information relevant to immediate task execution visibly or audibly in the interface. Thus, remembering certain task-related knowledge becomes unnecessary, which relieves working memory. Examples are visual feedback aids such as "graying out" nonapplicable menu items. On the contrary, when certain needed task-related information is not externalized on the interface, it needs to be internalized, stored in working memory and long-term memory. In many task situations, having the user acquire more knowledge of the structure of the task or its underlying rules is desirable. We examined the hypothesis that while externalization will yield better performance during initial learning, internalization will yield a better performance later. We furthermore expected internalization to result in better knowledge, and expected it to provoke less trial-and-error behavior. We conducted an experiment where we compared an interface with certain information externalized versus not externalizing it, and measured performance and knowledge. In a second session 8 months later, we investigated what was left of the participants'

knowledge and skills, and presented them with a transfer task. The results showed that requiring internalization can yield advantages over having all information immediately at hand. This shows that using cognitive findings to enhance the effectiveness of software (especially software with specific purposes) can make a valuable contribution to the field of human-computer interaction.

INTRODUCTION

Humans interact with information in the world around them by taking it in, processing it, and outputting reactions. To process information, they use cognitive skills such as thinking, learning, reasoning, recognizing, and recalling, as well as metacognitive skills, which entail thinking about cognition (for instance, planning, strategizing, or choosing between reasoning or calculation types). Cognitive science studies these domains of human thought. Much research in this field is done through the analysis of subject reactions to presented information. This makes cognitive science a source of knowledge that could—and does—guide interface and system designers toward a more effective presentation of information in computer systems. We believe that utilizing cognitive findings to enhance the effectiveness of software can make a valuable contribution. Increasingly humans exchange information with the aid of computers, for instance, in education, entertainment, office tasks, information search, e-mail, and many other domains. Advances in computer and multimedia technology ensure that the format of this information is increasingly diverse using multiple media. Moreover, programs can have hundreds of functions. However, progression becomes difficult with this complexity of choices and representations. Harnessing this complexity to make it manageable for humans gave rise to the domain of "usability." Soon, among other things, the importance of minimizing user memory load became apparent. This resulted in recommendations to simplify the interface, restricting available options to those needed to carry out the task action at hand, and to keep options visible on the interface so users could interact on the basis of recognition rather than recall (Nielsen, 1994). In other words, the aim was just-in-time delivery of just the right information, obviating the need for memorization and extensive search in memory.

Our research does not aim at uncovering more principles that make systems even more usable, intuitive, or appealing. It goes beyond plain usability and focuses on how to shape interfaces that induce a user to learn cognitive and metacognitive skills, and thereby learn about the domain underlying the interface. We would like to find patterns of human behavior occurring with computer use, to find out what kind of *behavior* certain decisions in interface design provoke, not only during interaction, but also after delays and in transfer situations. In this, we feel that one continually has to consider the real purpose of the system. If a system ought to teach material to students or children, or needs to make sure that users do not mindlessly follow interface cues because the task to perform is of a certain crucial nature, then we should know what it is about an interface design that induces people to think and learn. In this chapter, the focus is on *internalization* and *externalization* of information, and how this may lead to different behavior on the user's part. In the following sections, we explain the different terms used in this context. After this, we will look at the pros and cons of externalizing and internalizing information, and some effects of varying interface elements on learning and metacognitive processes. In the next sections we discuss an experiment on users' behavior that two interface styles (internalization and externalization) provoke, and more specifically, the amount of planning and learning from the users' side. In the concluding section, we discuss our findings and lay out our future plans.