Attention Aware Systems

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INTRODUCTION

Much information science research has focused on the design of systems enabling users to access, communicate, and use information quickly and efficiently. However the users' ability to exploit this information is seriously limited by finite human cognitive resources. In cognitive psychology, the role of attentional processes in allocating cognitive resources has been demonstrated to be crucial. Attention is often defined as the set of processes guiding the selection of the environmental stimuli to be attended. Access to information therefore is not only regulated by its availability but also by the users' choice to attend the information—this choice being governed by attentional processes. Recently several researchers and practitioners in Human Computer Interaction (HCI) have concentrated on the design of systems capable of adapting to, and supporting, human attentional processes. These systems, that often rely on very different technologies and theories, and that are designed for a range of applications, are called *attention-aware* systems (AAS). In the literature, these systems have also been referred to as *Attentive User Interfaces* (Vertegaal, 2003). However, we prefer using the former name as it stresses the fact that issues related to attention are relevant to the design of the system as a whole rather than limited to the interface. The recent interest in this field is testified by the publication of special issues in academic journals (e.g., *Communication of the ACM, 46*(3), 2003; *International Journal of Human-Computer Studies, 58*(5), 2003) and by the organisation of specialised fora of discussion (e.g., the workshop on "Designing for Attention"; Roda & Thomas, 2004).

In this article, we discuss the rationale for AASs and their role within current HCI research, we briefly review current research in AASs, and we highlight some open questions for their design.

BACKGROUND: RATIONALE FOR AND ROLE OF ATTENTION-AWARE SYSTEMS

In this section, we analyze the rationale for AASs and we discuss their role in HCI research.

Why Attention-Aware Systems?

Information overload is one of the most often mentioned problems of working, studying, playing, and generally living in a networked society. One of the consequences of information overload is the fast shift of attention from one subject to another or one activity to another. In certain situations, the ability to quickly access several information sources, to switch activities, or to change context is advantageous. In other situations, it would be more fruitful to create and maintain a focus while offering the possibility to switch attention to other contents or activities only as a background low-noise open choice. System awareness about the cost/benefits of attentional shifts with respect to the users' goals is essential in environments where (1) attentional switches are very often solicited, or (2) where the users' lack of experience with the environment makes it harder for them to select the appropriate attentional focus, or (3) where an inappropriate selection of attentional focus may cause serious damage to the system, its users, or third parties. Systems relying highly on multi-user interaction, such as virtual communities and certain systems supporting cooperative work, are examples of environments where attentional switches are often solicited. Online educational sys-

tems are examples of environments where the lack of knowledge and experience of users with the subject at hand makes it harder for them to select the appropriate attentional focus and may easily cause a loss of focus. Life critical systems are examples of environments where an inappropriate selection of attentional focus may cause serious damage. The need for *AAS*s is quite widespread especially if one considers that assessing, supporting, and maintaining users' attention may be desirable in other environments such as entertainment and e-commerce.

Attention-Aware Systems in HCI Research

A large portion of research on human attention in digital environments is based on the findings of cognitive psychology. For example, Raskin (2000) analyses how single locus of attention and habit formation have important consequences on human ability to interact with computers. He proposes that habit creation is a mechanism that can be used to shift the focus of users from the interface to the specific target task.

This study follows the classic "direct manipulation" school (Shneiderman, 1992, 1997) which aims at supporting the attentional choices of the user by making the device "transparent" so that the user can focus on the task rather than on the interface. The wide range of systems designed with this aim is often referred to as *transparent systems*, a term also employed in ubiquitous computing (Abowd, 1999; Weiser, 1991).

Another area of research focuses instead on designing interfaces and systems capable of guiding the users in the choice of attentional focus. The system is seen as proactive, visible, and capable of supporting the users in their choices. These types of systems are often designed as artificial agents (Bradshaw, 1997; Huhns & Singh, 1997) acting as proactive helpers for the user (Maes, 1994; Negroponte, 1997), and they are frequently referred to as *proactive/adaptive systems*.

The two approaches are often regarded as divergent: (1) responding to different needs and (2) requiring different design choices. However this is not necessarily the case, as it should become apparent from the following discussion of these two alleged differences on users' needs and design choices. Concerning the ability to respond to user needs, consider for example, one of the metaphors most often used for proactive systems: Negroponte's English butler (Negroponte, 1995). "The best metaphor I can conceive of for a human-computer interface is that of a well-trained English butler. The 'agent' answers the phone, recognizes the callers, disturbs you when appropriate, and may even tell a white lie on your behalf. The same agent is well trained in timing, versed in finding the opportune moments, and respectful of idiosyncrasies. People who know the butler enjoy considerable advantage over a total stranger. That is just fine" (p. 150). Isn't this proactive/adaptive system an exquisite example of a transparent system? The English butler certainly knows to disappear when it is the case, but he is there when required and is capable of proactive behavior such as selecting the calls you may want to receive or even telling a joke if appropriate! Concerning the design choices, a few considerations should be made. First of all, any system needs to be proactive in certain situations (e.g., reporting errors) and transparent in others. Secondly, certain applications, in particular those where the user has a good knowledge of the most effective attentional focus, require mostly transparent interfaces, while certain others, where the user is more in need of guidance, require more proactive interfaces. Also the users' needs, the system's functionality, and the use that is made of the system, may change with time. Therefore, it may be desirable for a system, that is initially very proactive, to slowly become transparent, or vice-versa. Finally, applications exist where the user is expected to focus on the system/interface itself, that is, digital art. As a consequence, just as proactive adaptive behaviors may not always be desirable, transparency itself may, under certain conditions, not be desirable.

This brings us to another reason for studies related to AASs. In the last two decades, there has been a shift on the use and market of Information and Communication Technologies (ICT) from strictly task oriented (work related) to more of a pervasive personal and social use of these technologies. Performing a task or achieving a goal may not be the main target of the user who instead may turn to ICT artifacts for their symbolic or affective value, entertainment, or pleasure in general; see, for example, Lowgren's arguments for Interactive Design versus