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Benefits and costs of adaptive user interfaces

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Abstract

The paper examines the positive and the possible adverse effects of adaptive user interfaces (AUIs) in the context of an in-vehicle telematic system as a function of four factors: (1) four different levels of adaptivity (ranging from manual to fully adaptive with intermediate levels); (2) different tasks; (3) routine (familiar) and non-routine (unfamiliar) situations; and (4) different user age groups. Both experiments included three sessions during which participants drove a simple driving simulator and performed tasks with the telematic system at one of the adaptivity levels. We measured task performance times and lane position variance. Adaptivity was not always equally beneficial, and its benefits depended on a number of factors, including the frequency in which the tasks were performed, the user's age, the difficulty of the task and the user's involvement in the task. In familiar, routine situations, a fully adaptive system was beneficial for all participants, particularly older ones. In unfamiliar situations, to which the AUI was not adjusted, cognitive workload increased substantially, adversely affecting performance. Intermediate levels of adaptivity keep users involved in the task and help them become more proficient when performing both routine and non-routine tasks. However, intermediate levels of adaptivity should also be implemented with care, because they may also have adverse effects when users encounter non-routine situations.

Keywords: Adaptive user interface; Levels of adaptivity; Task frequency

1. Introduction

Adaptive user interfaces (AUIs) are defined as systems that adapt their displays and available actions to the user's current goals and abilities by monitoring user status, the system state and the current situation (Rothrock et al., 2002). The use of AUIs supposedly helps to improve user interaction with systems by facilitating user performance, minimizing the need to request help, easing system use, helping users deal with complex systems and avoiding cognitive overload problems (Browne et al., 1990; Edmonds, 1993; Hook, 1998, 1999; Trumbly et al., 1994). These benefits are apt to disappear (or are minimal) when AUIs violate usability design principles. For instance, AUIs are almost inherently inconsistent over time i.e., their interface or functionality may change. For additional examples of the possible usability problems that may arise from adaptivity, see Jameson (2003), Hook (1999), Keeble, Macredie (2000), Kuhme (1993) and Shneiderman (1997).

In spite of major progress in AUI research, we still lack a methodology for determining when and how adaptivity should be implemented. These decisions should be based on understanding the conditions in which benefits from adaptivity outweigh possible costs. In this paper we propose that AUI properties cannot be evaluated in isolation. Instead, one must consider the circumstance in which the system is used, the user population and other factors. For instance, the same algorithms for adaptation and the same interface may be very efficient in some contexts in which the system is always used the same way, and they may be very inefficient in other contexts in which system use varies more. We refer to this complex set of variables as the ecology of the system. Rather than focusing on one specific factor for determining whether adaptivity will be beneficial, we maintain that it is necessary to look at the whole ecology of system use. By looking at the wide range of relevant factors, system

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designers will be in a better position to provide users with the systems they truly need and which serve their interests.

1.1. Conditions for successful adaptivity

Only few studies have attempted to map the conditions under which adaptivity can be beneficial, as opposed to the conditions in which it will have an adverse effect. Instead, most studies presented examples of successful and unsuccessful adaptation methods without looking at the causes for their success or failure (Gajos et al., 2006).

Findlater and Mcgrenere (2004), for example, compared static, customizable and adaptive versions of split menus, and they found somewhat different results under different circumstances. For example, subjects better understood the benefits of customization (i.e., placing the frequently used items near the top) when they were given the static or adaptive menu before the customizable menu, compared to when the customizable menu appeared first. In a more recent study, Findlater and Mcgrenere (2008) have shown that AUIs are more beneficial when screen real estate is constrained, and that the adaptive accuracy conditions were better in the small screen displays compared to the desktop sized displays. Tsandilas and Schraefel (2005) examined the impact of accuracy of two adaptation techniques (highlighted menu items vs. reduced font size of non-suggested items) applied to lists of textual selections. They concluded that the effectiveness of different adaptation techniques varies according to the accuracy of the prediction mechanism.

Gajos et al. (2006) addressed more explicitly which aspects of AUIs affect their success. They found the predictive accuracy of the AUI to have a significant impact on user performance. Based on previous research they also claim that the frequency of adaptation largely impacts the relative weights users assign to the different costs and benefits of adaptation. Slow paced adaptation, as applied by Sears and Shneiderman (1994), provided benefits (compared to the non-adaptive baseline), while fast paced adaptation, as used by Findlater and Mcgrenere (2004), leads to negative results. Finally, they demonstrated that the frequency of the interaction with the interface and the cognitive complexity of the task affected the aspects the users find relevant. Recently Gajos et al. (2008) showed that in addition to accuracy, the predictability of the AUI increased user satisfaction.

1.2. Factors involved in the interaction with AUIs

We suggest four key factors that determine the value of adding adaptivity to a system (in addition to the aspects described above)—the task, the user, the situation and the level of adaptivity.

1.2.1. The task

Tasks vary in many aspects, including their particular characteristics, difficulty level and what they require from the user. An AUI, for example, may be more beneficial for performing difficult rather than easy tasks. Additionally, some tasks require motor skills, while others may necessitate various cognitive skills. The outcome of using an AUI may change according to particular task requirements. Our research will look at different levels of task difficulty and how the difficulty affects the interaction with AUIs.

1.2.2. The user

Users differ in a wide range of variables, including demographic characteristics, background, education, personality, cognitive skills and preferences. Users' motivation, goals and moods also vary. Different users may interpret command names and icons differently and will attend to different aspects of computer displays (Benyon and Murray, 1993). One of the major challenges in the study of human–computer interaction is the question how to deal effectively with individual differences, preferences and experience. Different users may benefit differently from AUIs. We focus in our study on age, a user characteristic that is relevant in a wide range of situations. In our experiments we assess the differences between younger and older users in the benefits they derive from AUIs.

1.2.3. Routines versus non-routines

AUIs monitor user behavior over time, and they adjust the interface or the system functioning to the frequency of the tasks the individual user performs. Consequently, AUIs usually provide good support when users perform routine, frequent tasks. For example, an adaptive menu may provide users with easier access to frequently used menu items by displaying them at the beginning of the menu. However, at times users may need to perform infrequent, non-routine tasks. In such cases, when, for example, the user needs to search for a rarely- or never-used menu item, the AUI ceases to provide any benefits. It may, therefore, be valuable to differentiate between routine and non-routine tasks when examining AUIs. Only few studies have looked at the effects of task frequencies in the context of AUIs (see Bunt et al., 2004, for example). In our study we examine the effects of AUIs on the performance of routine and non-routine tasks.

1.2.4. Levels of adaptivity

We maintain that AUIs should not be viewed merely as having or not having adaptive features. Instead, AUIs can employ different levels of adaptivity. Levels of adaptivity relate to the question whether the system solely controls adaptation or whether adaptation is a co-operative process between the user and system. Several researchers have examined the question of allocating the control of the interaction between the user and system and offered