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# Customization of user interfaces to reduce errors and enhance user acceptance

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ABSTRACT

Customization is assumed to reduce error and increase user acceptance in the human–machine relation. Reconfiguration gives the operator the option to customize a user interface according to his or her own preferences. An experimental study with 72 computer science students using a simulated process control task was conducted. The reconfiguration group (RG) interactively reconfigured their user interfaces and used the reconfigured user interface in the subsequent test whereas the control group (CG) used a default user interface. Results showed significantly lower error rates and higher acceptance of the RG compared to the CG while there were no significant differences between the groups regarding situation awareness and mental workload. Reconfiguration seems to be promising and therefore warrants further exploration.



## 1. Customization of user interfaces and expected outcomes

The basic idea of individuation is "to explore ways through which each and every single individual can customize his or her own tools to optimize the pleasure and efficiency of his or her own personal interaction" (Hancock et al., 2005, p. 12). Thus, according to the idea of individuation, technological tools such as user interfaces should be customizable and adaptable to individuals with the aim of increasing efficiency and safety (Hancock et al., 2005). In the context of this study, individuation is perceived as the perfected or accomplished form of customization. Individuation and customization are assumed to increase an individual's perception of control over the environment. Perceived control satisfies the need for autonomy and therefore, has been shown to increase job satisfaction, work motivation, and positive affect (Fritzsche and Parrish, 2005, cited in Hancock et al., 2005).

According to Pozzi and Bagnara (2011), research on customization within the field of human–computer interaction is increasing and the focus in design is changing from designing for average users to designing for individuals. Empirical research has shown that user performance is enhanced when characteristics of user interfaces are matched to the skill levels of users (Trumbly et al., 1994). In the present study, we focus on customization of user interfaces and aim at studying whether performance in a process control task can be enhanced through customization of user interfaces.

In our study, participants were provided with a reconfiguration tool which allowed them to customize their user interface to their own preferences. The reconfiguration tool allowed different reconfiguration operations such as the duplication or removal of interaction elements (e.g., buttons or sliders) or the discretization of continuous interaction elements, generating various values in a given interval (e.g., sliders), into one discrete interaction element (e.g., buttons), generating only one specific value out of the range the former defined interval (e.g., button; Weyers et al., 2010). Thus, both, the reconfiguration of the interaction logic (defining the data-based communication between user and the system to be controlled) as well as the reconfiguration of the physical representation of the user interface were possible. A computer-based simulation of a feedwater circuit of a nuclear power plant was employed as a process control task. This process control task involved controlling and operating the reactor and running procedures such as start-up and shut-down, and dealing with fault states (Weyers et al., 2012).

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### *1.1. Reducing errors through correspondence of mental model and physical system*

We expect the customization of user interfaces, i.e., the possibility to reconfigure one's own user interface, to enhance performance in process control. This assumption is based on considerations on the importance of an operator's mental model of the system (e.g., the reactor). A mental model is defined as "a mental structure that reflects the user's understanding of a system" (Carroll and Olson, 1987; cited in Wickens and Hollands, 2000, p. 280). The mental model forms the basis "for understanding the system, predicting its future behavior, and controlling its actions" (Wickens and Hollands, 2000, p. 132). An accurate mental model of the system is therefore essential for successful performance. However, mental models can be inaccurate which can decrease performance and increase the chance of operator errors. Effective user interfaces require the correspondence of the following three levels of representation: (1) the physical system, (2) the operator's mental model, and (3) the user interface between the system and the operator (Wickens and Hollands, 2000, p. 133). We suggest that this correspondence between levels of representation can be improved with the customization of user interfaces. With the reconfiguration tool, the operator can reconfigure his or her user interface (level 3) corresponding to his or her own mental model of the system (level 2) while the physical system (level 1) will be left untouched. This increased correspondence is expected to reduce errors, because the operator can ensure an intuitive and effective user interface organized according to the physical system (cf. Wickens and Hollands, 2000; Weyers et al., 2012). We assume that the process of reconfiguration can lead to a better mental model of how to control and handle the system. This mental model of handling and control of a system may be individual and cannot be predicted for every operator. Therefore, reconfiguration of user interfaces according to individual mental models is assumed to enhance performance and support operators. However, an inaccurate mental model may lead to a non-optimal user interface which may increase errors and present a risk to safety. Therefore, it is suggested to incorporate a safety check of reconfigured user interfaces by experts especially in safety-relevant fields and industries.

### *1.2. Enhancing user acceptance*

We expect customization to support not only process control performance but also increase acceptance of the user interface. The technology acceptance model (e.g., Davis et al., 1989) aims at predicting the acceptance of a certain technology or computer system from intentions measured by attitudes, perceived usefulness, and perceived ease of use (Davis et al., 1989). The model is based on the theory of reasoned action by Ajzen and Fishbein (1980) which has been empirically tested in a range of different domains and shown to be able to predict behavior (Davis et al., 1989). The technology acceptance model is more specific than the theory of reasoned action in that it is tailored to computer usage behavior (Davis et al., 1989). The technology acceptance model suggests that the two beliefs *perceived usefulness* and *perceived ease of use* determine the behavioral intention to use a certain technology or computer system, which is related to subsequent behavior (Davis et al., 1989; Venkatesh, 2000). Perceived usefulness refers to "the prospective user's subjective probability that using a specific application system will increase his or her job performance" and perceived ease of use is defined as "the degree to which the prospective user expects the target system to be free of effort" (Davis et al., 1989, p. 985). The technology acceptance model is a widely employed model of user acceptance and has been empirically supported in different studies (Venkatesh, 2000; Taylor and Todd, 1995). The model's variables have also been operationalized and the scales and items have been validated (e.g., Venkatesh, 2000). In the present study, we will measure user acceptance based on the technology acceptance model, because we aim at evaluating computer-based user interfaces with a theoretically and empirically supported model. Research within the context of human-adaptable automation has shown that flexibility can increase user acceptance (Miller and Parasuraman, 2007). Therefore, we expect that customization of user interfaces will increase user acceptance.

### *1.3. Enhancing situation awareness and reducing mental workload*

Situation awareness is referred to as the perception and comprehension of information and the projection of the information status in the near future (Endsley, 1995b). Situation awareness is important for safety and performance since poor situation awareness such as incomplete or inaccurate situation awareness increases the probability of human error. Therefore, situation awareness has received increased attention in user interface design. According to Endsley (1995b), user interface design can have a great impact on situation awareness because the design of a user interface determines the quantity and accuracy of information acquired and the degree of compatibleness of the user interface with the user's situation awareness needs. Therefore, Endsley (1995b) suggests to design user interfaces in a way "that will transmit needed information to the operator without undue cognitive effort" (p. 50). Thus, both mental workload and situation awareness should be considered in user interface design (Endsley, 1995b). Based on these considerations regarding situation awareness and mental workload, we assume that situation awareness will increase with the possibility to reconfigure user interfaces. The underlying reasoning is that when reconfiguring user interfaces, the operator can choose a way to present information that suits his or her preferences. Furthermore, we assume that operators will come up with a user interface that displays needed information with little effort. Therefore, we expect that an effectively designed user interface can help to reduce mental workload (Endsley, 1995b).

## 2. Method

### *2.1. Participants and design*

In all, 72 participants (12 female, gender unknown: 4) took part in this between-subjects design involving two groups. The experimental group, i.e. the reconfiguration group (RG; $n = 38$, 6 female), trained and worked with the reconfigurable user interface while the control group (CG; $n = 34$, 6 female) trained and worked with the initial user interface. Participants were students of applied computer science and they participated in the study for course credit. Their ages ranged from 19 to 41 years with an average age of 22.7 years ($SD = 4.3$ years).

### *2.2. Experimental task*

We employed a simulation of a feedwater steam circuit of a nuclear power plant as an experimental task (see Fig. 1). The simulation was based on an implementation by Eriksson (2012). More detailed information on the simulation can be found in another article by Weyers et al. (2012) which is based on the same study but focuses on formal modeling and reconfiguration of user interfaces whereas the focus of the present article is on the psychological aspects of reconfiguration. The main tasks of the operator were (a) to keep the reactor in a safe system state by keeping the water level in the reactor tank constant (at 2100 mm) and to prevent accidents from happening, (b) to generate a constant