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The impact of paper prototyping on card sorting: A case study ☆

Karin Slegers [a,*], Verónica Donoso [b]

[a] CUO | Social Spaces, KU Leuven (University of Leuven)/IBBT, Parkstraat 45, Box 3605, 3000 Leuven, Belgium
[b] Institute for Media studies, KU Leuven (University of Leuven), Parkstraat 45, Box 3603, 3000 Leuven, Belgium

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ABSTRACT

Combining the techniques of paper prototyping and card sorting into a single session has the benefits of helping users to understand a new technology on the one hand, and of gaining insight into the users' mental models of that technology on the other hand. However, acquainting users with a new technology via a paper prototype might affect their mental models, as assessed with the card sorting technique. The aim of this paper was to explore the possibility of combining the two techniques in a single research session. Thirty-seven users participated in a study concerning a payment system based on Near Field Communication (NFC). Eight group sessions were organized, including both a paper prototyping exercise and a card sorting exercise. The order of the exercises was alternated. The findings of this case study seem to suggest that the paper prototyping exercise resulted into deeper insights into the participants' mental models resulting from the card sorting exercise. At the same time, paper prototyping seemed to prevent participants to come up with new names for their card sorting categories.

1. Introduction

User-centered design is an approach for designing products and applications based on information concerning the problems, needs, interests and capabilities of the potential users (e.g. Norman, 1988). Essential to this approach is to explicitly focus on the users in all phases of product development and to actively involve users in those phases. Common research methods in user-centered design include ethnographic methods (e.g. observation, contextual inquiry, interviews) as well as usability research methods (e.g. task analysis, cognitive walkthrough, usability testing).

Because individual user-centered design methods usually focus on a specific aspect of the users (e.g. a specific task, or specific user characteristics) is quite common in user-centered design to combine several methods and techniques. Approaches such as mixed methods design or multimethod design are considered essential to gain a complete understanding of behavior and user experience (e.g. Morse, 2010). While such approaches usually refer to combining qualitative and quantitative research methods, combinations of several qualitative methods can also be very useful to gain a better insight into the users. Although combining qualitative methods into one research project, or even into single research sessions, is quite common practice in user-centered design research, little is known about the mutual impact of the methods used. It is important to understand this mutual impact in order to correctly interpret the results of the research performed. In case, for instance, one method has an effect on participants' behavior, attitudes, or opinions, the results of any additional method may be affected subsequently. In this paper we present a study that included two common methods in user-centered design: card sorting and paper prototyping. Although the study was not set up to experimentally test the mutual impact of the methods used, it provides an interesting case study to explore this mutual impact.

Card sorting and paper prototyping are two qualitative techniques that are frequently applied in user-centered design and in human–computer interaction research. Both techniques are especially useful in the design of innovative applications. Such applications often involve new and unfamiliar technologies or interaction styles. To make sure that the user interface design of a new application and the interaction between users and the application are usable, it is essential to understand the users' mental models in an early stage of the design process and to actively and iteratively involve the users throughout the design process.

A method that is often used to make sure that conceptual models and user interfaces of new applications match the mental models of the end-users is card sorting (Stone et al., 2005; Brinck et al., 2002; Courage and Baxter, 2005). Card sorting allows researchers to explore the way end-users group items into categories and concepts. When performing a card sorting exercise, names of items (e.g. menu items) are printed on cards. These cards are shuffled, after which end-users are asked to group the cards into categories that they consider meaningful. Subsequently, the end-users give each of the categories a suitable name. Designers may use the

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* Corresponding author. Tel.: +32 16 32 36 52; fax: +32 16 32 32 10.
E-mail addresses: Karin.Slegers@soc.kuleuven.be (K. Slegers), Veronica.Donoso@soc.kuleuven.be (V. Donoso).

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insights gained from card sorting exercises as input for the user interface design, especially with respect to the structure of the interface menus and to terminology. In addition, card sorting provides information about which items are missing, which items were not expected by end-users, or which items should be renamed.

Since innovative applications often involve new and unfamiliar technologies or interaction styles, these are typically very difficult for end-users to understand. In order to form realistic mental models, it is essential that users thoroughly understand the new concept and the consequences of its use in their everyday lives. Moreover, it is believed that mental models consist of the user's knowledge of a system, resulting in a model that describes and predicts the system's performance as expected and perceived by the user (Jonassen, 1995). Thus, before conducting a card sorting exercise, researchers need to make sure that the users understand the potential use and impact of a new application. Or, as Rugg and McGeorge put it (Rugg and McGeorge, 1997, p. 84): "Card sorts require the respondent to know about the entities named on the cards; it is not possible to use entities unknown to the respondent".

An efficient technique to explain a new application to users in very early phases of the design process is paper prototyping. Low fidelity prototypes, such as paper prototypes, are considered an efficient way of visualizing and communicating concepts and of demonstrating and evaluating interactions without having to invest much in technical development yet (Stone et al., 2005; Jonassen, 1995; Snyder, 2003).

Typically, paper prototypes are created in the early phases of designing and developing new applications and are used as a tool to facilitate communication between designers or researchers on the one hand and end-users on the other hand (Beyer and Holtzblatt, 1998). Paper prototypes usually are sketches of the user interface design, possibly including moveable parts to represent interface elements (e.g. buttons, windows, menus) (Benyon et al., 2005). They allow the representation of action-oriented elements in an interface and of more aesthetically driven aspects (Brinck et al., 2002). As such, paper prototypes are useful to evaluate the design with users or to test the usability of the interfaces by asking users to carry out real-life tasks with the prototypes. In the latter case, the users select options or actions and the researcher shows the next interface state. Doing such tests may reveal usability problems in a very early phase of the design process and at the same time allows users to gain early hands-on experience with an interface, facilitating user experience evaluation at this stage (Reilly et al., 2005).

Combining the techniques of paper prototyping and card sorting seems a promising approach for the design of innovative applications since it allows for assessing users' mental models while making sure that the users understand the concept of the application thoroughly. As a result of using this combination of techniques, more realistic mental models may be assessed than using card sorting alone. On the other hand, a possible disadvantage of this combination of techniques is that presenting users with a paper prototype could affect their mental models. When sorting the cards, users might simply copy the model of the application that was presented to them in the form of the paper prototype, instead of forming their own mental models. In that case, the results of a card sorting exercise following a paper prototype exercise do not represent the mental models of the users, but rather those of the designers who created the prototype in the first place. Very little research has been reported showing such an influence of paper prototyping on card sorting, except for some case study descriptions (e.g. Spencer (2009) described card sorting results that were influenced by a previous usability test (p. 12)). Therefore, it is important to understand the influence of explaining new applications to users via paper prototypes on the formation of users' mental models.

The aim of this paper is to explore the effect of explaining a new application to end users by means of a paper prototype on the results of a subsequent card sorting exercise involving elements from that new application. In the study described here, the order of the paper prototyping exercise and the card sorting exercise was manipulated in test sessions with end-users. By alternating this order between groups of users, the mental models of users who had been presented with a paper prototype could be compared to mental models of those users who had not.

1.1. Context: Near Field Communication mobile payment

The test sessions were organized within the framework of a project in which a Near Field Communication (NFC) mobile payment application was developed (Slegers, 2008a,b). NFC is a wireless communication technology that enables the exchange of data between devices over a distance of about ten centimeters (Ortiz, 2010). Increasingly more mobile phones are equipped with NFC technology, allowing for the use of the mobile phone for services such as wireless payment, ticketing, and smart posters. The application that was used in the current study runs on a mobile handset that connects to a cash terminal via NFC when the two devices touch.

The scope of the payment application is on vouchers, and in particular on so-called "meal vouchers". Meal vouchers are commonly issued in Belgium by employers to compensate for the fact that no free-of-charge meal is offered in a corporate restaurant. For both employers and employees, meal vouchers offer certain fiscal advantages. Meal vouchers typically have a value in the range of 5–10 Euros and employees receive one voucher for each working day every month. Meal vouchers can be used to pay for food in many food stores and restaurants. Each month, in combination with the meal vouchers, employees also receive a number of discount coupons for several products.

The research that was conducted for the development of this new NFC meal voucher application followed a user-centered design approach. This was done for two main reasons. The first reason was related to the fact that a completely new application was developed. Such a completely new application allows designers to ensure a close match between the users' needs on the one hand, and the functionality, usability and user experience of the application on the other hand. In addition, it provides an opportunity for creating a solution to the problems users experience with the current paper meal vouchers. The first phase of the user-centered design research aimed at assessing the users' needs and current problems and included interviews, observations and co-creation sessions. The results of this first research phase have been described in [Removed for anonymous review].

A second reason for following a user-centered design approach was the fact that most potential end-users of the new mobile payment application are still very unfamiliar with NFC-technology or with touch-based interactions. Therefore, when designing such a new application, it is important to thoroughly understand the users' mental models of such technologies and interactions. The aim of the second phase of the user-centered design research, of which the study described in this paper was a part, was to understand the potential end-users' mental models of NFC technology in general and of the concept of the NFC-enabled meal voucher in particular. For this purpose, a card sorting exercise was conducted. This information about the mental models resulting from this exercise would be used as input for the user interface design of the NFC meal voucher application.

In the first research phase of the project we learned that users had difficulties to understand the concepts of NFC technology