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Designing Internet-Based Payment Systems: Guidelines and Empirical Basis

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ABSTRACT

This article describes research into online electronic payment systems, focusing on the aspects of payment systems that are critical for their acceptance by end users. Based on our earlier research and a diary study of payments with an online payment system and with online banking systems of a reputable bank, we proposed a set of 12 interaction design guidelines. The guidelines have been applied during the implementation and redesign of a new payment system. An extensive experimental comparison of the original version of the system with the one de-

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signed according to the design guidelines has provided confirmation of the relevance and adequacy of these guidelines for designing online payment systems.

1. INTRODUCTION

Human–computer interaction research in the domain of E-Commerce has advanced significantly over the last 10 years, providing practical guidance in the form of design guidelines, for example, see Nielsen, Molich, Snyder, and Farrell (2000). There are also theory-motivated works describing purchasing attitudes and behavior (e.g., Koufaris, 2002), or models and methods guiding

the design of commercial Web sites to encourage trust on the part of customers (e.g., Cofta, 2006; Egger, 2003; Teo, Oh, Liu, & Wei, 2003). The understanding of interaction design issues in relation to E-Commerce is growing in breadth and depth together with the increasing adoption of E-Commerce by consumers across the globe.

Despite the fact that electronic commerce has reached a mainstream status and high adoption rates, its future progress is to a large extent hampered by the lack of appropriately designed Electronic Payment Systems (EPSs). According to a survey by Jupiter Research (2000), credit cards were still the dominant payment method for online purchases, accounting for up to 95% of online transactions in the United States, whereas about 85% of all Internet transactions worldwide are still transacted via credit cards that were not designed originally for the Internet (Philippsohn & Thomas, 2003). The need for new payment systems specifically designed for online transactions has been clearly identified by earlier research (Guttmann, 2003; Laudon & Traver, 2002; Lynch & Lundquist, 1996; Wayner, 1997).

Currently, the state of the art for online EPSs is far from ideal. A survey of electronic money developments by the Bank for International Settlement reports a rather low-level adoption of online EPSs, even in the most advanced countries (Bank for International Settlements [BIS], 2000; ECB, 2001). The lack of customer demand, the diversity of current technological standards, and the lack of support by financial institutions have been suggested as some of the reasons slowing down the adoption of online EPSs (ECB, 2003).

This article concerns human–computer interaction research aimed at proposing and validating interaction design guidelines for Internet-based payment systems. The work presented focuses on Business-to-Consumer (B2C) Internet E-Commerce, and specifically on online EPSs designed with the purpose of facilitating payments for consumer E-Commerce. The transactions considered are especially those related to buying goods and services that are common in B2C E-Commerce. Different payment systems may be more appropriate for different amounts of money. To limit the scope of our investigation for the domain of business to consumer E-Commerce, we do not consider large payments (typically this means larger than 1,000) that are best handled through banking systems, and small payments (typically taken to mean less than 1), or even micropayments (amounts of a fraction of a cent) for which radically different user concerns and interaction requirements dominate (Kalakota & Whinston, 1997).

2. RESEARCH APPROACH AND OUTLINE OF THIS ARTICLE

Research into payment systems typically takes a business or systems perspective. To establish links between interaction design and user acceptance of

these systems we adopted a research approach typical for the field of human–computer interaction (e.g., see Mackay & Fayard, 1997; Rauterberg, 2006), triangulating empirical studies, theory development, and interaction design. Still, the specific domain of payment systems poses unusual challenges; target users include potentially and hopefully as many consumers as possible, and payment is by its nature privacy and financially sensitive. Research methods each bring about their own strengths and limitations, none being sufficient on its own for our purposes: Large attitude surveys help capture attitudes representative of large consumer groups but they do not help draw causal links between system attributes and acceptance, thus requiring triangulation with in-depth qualitative research studies even though the latter may be nonrepresentative and nongeneralizable. Furthermore, linking attitudes to system characteristics is not our end goal; we need concrete interaction design advice that can be shown to be useful in practice and usable by the professionals it is intended for. Recognizing the trade-offs associated with each research method, we have opted for an eclectic approach. The research reported next took place over 4 years, combined numerous studies, triangulating different research methods, with the aim to formulate and verify interaction design guidelines for payment systems.

Initially an extensive survey of prior research was conducted leading to an initial formulation of design guidelines for payment systems. Existing payment systems were analyzed to formulate and validate these initial guidelines. Section 3.1 presents a case study analysis comparing Chipknip™ and Chipper™ (Nannery, 1998) two smart-card-based EPSs for offline use deployed in the Netherlands and discusses how the interaction design of these EPSs has influenced user acceptance and eventual adoption (or lack of). Section 3.2 discusses PayPal, a popular Internet-based payment system illustrating how applying the guidelines to improve the interaction design of this system can address known user concerns flagged in Internet forums or related publications.

In parallel to these analytical activities an attitude survey regarding payments systems was conducted in cooperation with an established Dutch consumer organization (Consumentebond). On one hand, the survey provided a representative snapshot of consumer attitudes toward existing payment systems at the time; on the other, it helped understand the relative importance for payers of different aspects of payment systems. This survey involved 1,328 respondents and was reported extensively in Abrazhevich (2001a, 2001c, 2004); its results are not repeated here, as they have been incorporated into the design guidelines that we discuss extensively next.

Although the survey was based on a large and representative sample of consumers in the Netherlands and served well to understand their attitudes, it could not provide insight into how the design of a payment system can affect

these attitudes. For this reason, a detailed diary study of actual online payments with a small number of participants was conducted; some preliminary results were reported in Abrazhevich (2002); for a more extensive description readers are referred to Abrazhevich (2004).

The diary data and the data from the follow-up interviews were analyzed qualitatively aiming to draw causal links between interaction design attributes and acceptance of the payment system. As a result of this analysis, which is summarized in Section 4, we were able to articulate in a more operational form interaction design guidelines for Internet-based payment systems. By operational, we mean here that the description followed current standards for documenting interaction design guidelines with the intention to render these guidelines readable and usable to third parties and especially to professional interaction designers. Guideline descriptions included a summary, a detailed description, a summary of empirical basis, and examples of its application.

To ensure that applying these design guidelines leads to a better user performance and user acceptance of online EPSs, a case study was conducted (Section 6). This study involved two parts:

- A professional designer of payment systems used the design guidelines to evaluate a real-life online EPS, propose and carry out improvements thus identified.
- A comparative evaluation of the redesigned system versus the original version was carried out to assess the effectiveness of a subset of the design guidelines used.

It resulted in some modification and amendments to the set of guidelines, including feedback from the designer regarding their applicability and relevance. The article concludes with a summary of the guidelines as they have been shaped through the studies reported.

3. USER ACCEPTANCE: UNDERSTANDING AND ISSUES

User acceptance of sensitive technology such as money-circulating payment systems is a critical aspect of the whole path of the lifecycle of payment systems. Probably the most widely known predictive model of user acceptance is the Technology Acceptance Model (Davis, Bagozzi, & Warshaw, 1989) that focuses on the usefulness and usability of an information system as factors predicting its acceptance. Later research has also shown the impact of other factors that influence acceptance, such as the social and technological context. See, for example, the unified model of acceptance by Venkatesh, Morris, Davis, and Davis (2003). Indeed, research on E-Commerce and payment systems suggests that user acceptance of online EPSs may be influenced by a number of factors and

parties, encompassing the social context of online EPS using the Internet, marketing, publicity, the reputation of the bank behind the system, confidence in the company operating the system and in the technology behind the system, and the convenience of the user interface–see, for example, Egger (2003), Guttmann (2003), and Kalakota and Whinston (1997).

There are several obstacles to user acceptance of online EPSs (Abrazhevich, 2001b). In comparison with traditional commercial Web sites, EPSs not only have to sell a payment service to potential users but also have to convince the users to entrust their money to a third-party institution, to rely on the payment system for their business and personal finance, and to use it frequently. To attain this high level of trust, a user-centric approach would require that, from the very beginning of the development of an online EPS, the designers should bear in mind user-related factors. This point is illustrated clearly by the case of Chipknip and Chipper presented next, which highlights user-related factors pertaining to the acceptance of an EPS.

3.1 The Case of Chipknip and Chipper

The case of Chipknip and Chipper illustrates a failure of an (offline) EPS due to failure to focus on user and market needs. The Chipknip and Chipper smart card payment technologies (Nannery, 1998) were introduced in the Netherlands in the early 1990s. Both systems provided a way of handling everyday transactions involving small amounts that people would normally pay with cash. These two systems competed with each other for some time. They were incompatible, so customers could not pay with the competitor's card at points of sale, and this limited the user base for both systems (BIS, 2001). In most contexts where Chipknip and Chipper were available, payers did not feel the need for another payment system (Intermediar, 2005). Chipknip and Chipper duplicated the functions and applications of debit cards without providing significant benefits in ease of use or range of applications. They did not address the needs that smart card systems are best suited to, for example, for small payments at parking lots, vending machines, and public transport tickets machines. Further problems related to the high costs for retailers of accepting Chipknip. As a result, the union of Small and Medium Enterprises of the Netherlands threatened to boycott Chipknip (HFD, 2001). In this case, an important factor stimulating the development of EPSs–that is, the reduced operational and processing costs–was not met.

All these issues led to low acceptance of Chipper and Chipknip technologies. Eventually, Chipper International decided to stop operations and the support of Chipper in the Dutch market (BIS, 2001; Libbenga, 2001). Chipper fused with Chipknip, and although some issues have been addressed, payers are still not turning to these technologies in large numbers. In 2004,

only 127 million transactions were made with Chipknip, compared to 1.25 billion made with debit cards. Apparently, consumers do not use the system because they first have to load the smart card with money (which takes time and effort) and, furthermore, they are afraid to lose the card and, with it, the loaded amount (Intermediar, 2005). This example illustrates how both user and marketing factors influence the eventual success of an EPS. For the successful user-centered design of online EPSs it is important to identify how user-related factors of payment systems impact on user acceptance, and which of them can cause problems when neglected in the design process.

3.2 Analysis of a Popular Online Payment System

As an example, consider PayPal, one of the most successful online payment systems on the market in the last few years. To be able to pay and receive money, a user has to open an account with PayPal. The account can be funded with credit or debit cards, electronic wire transfers, or other means. Registered customers can transfer funds between their accounts, pay at Web sites that accept PayPal payments, and receive money from other users. PayPal is used by major online companies such as eBay and Amazon.com. At the end of 2004, PayPal had already attracted more than 80 million user accounts rising to 150 million by 2008 (see http://www.paypal.com/).

In this section we consider PayPal with respect to a list of criteria that influence user acceptance of EPSs. These criteria were derived from a literature survey on EPSs (Abrazhevich, 2001c) and an extensive questionnaire-based survey of user attitudes toward such systems. The survey involved 1,328 participants and was conducted in cooperation with a Dutch consumer organization. The main outcome is the following list of relevant criteria for user acceptance. These criteria are presented next in order of importance as reported by participants in our survey. (For more details, see Abrazhevich, 2001a, 2004).

Criterion 1: Privacy of Users. PayPal users can expect a certain level of privacy when paying directly from a PayPal account. The company claims that "PayPal is committed to protecting the privacy of our users. When you send or request money using PayPal, the only information the recipient sees is your email address, date of sign-up, and whether you have completed PayPal's verification process by confirming an account at another financial institution. Recipients never see your financial information, such as your credit card or bank account numbers" (https://www.paypal-mainstreet.com/protecting-your-privacy-online). In general, Paypal provides satisfactory safeguards for user privacy, though clearly perceived privacy will vary across user and payment contexts.

Criterion 2: Trust in the System. An important predictor of usage of Internet-based services is the degree of trust in the system (Dinev & Hart, 2003). Trust may be developed on the basis of reputation or of previous expe-

riences with the system (Egger, 2003). Negative publicity regarding instances of poor performance of a payment system or incidents when governmental agencies have accessed the records of EPS operators may be very damaging to the reputation of online payment service providers and undermine user trust. In the case of PayPal, disenchanted customers have formed a number of bodies to inform and protect themselves and new users with respect to company policies and practices they consider contentious. In 2005 there were a few sites used by such groups such as www.paypalwarning.com, PayPal Victims Club at Yahoo! Groups, and www.aboutpaypal.org. Although PayPal does, in general, provide a trustworthy service, exposure of the public to such sources will result in less initial trust in PayPal than in, say, banks that enjoy a reputation for supporting traditional (non-Internet-based) financial transactions.

Criterion 3: Acceptability of the System for Sellers. Low user acceptance can also result from the experience that a particular system is not accepted by sellers as a means of payment. For this criterion, Pay Pal fares worse than more traditional means of payment. The main reasons for sellers refusing to accept PayPal payments, as reported in the aforementioned Internet communities, are periodic changes in PayPal's policy governing which products and services can be sold using the system. PayPal has been selective in associating itself with certain kinds of online businesses to protect its reputation; however, this policy has annoyed some sellers and users.

Criterion 4: Efficiency. PayPal is particularly efficient (e.g., small and micropayments are supported) in comparison with credit cards and debit cards for paying small amounts of money online. It allows transactions involving small payments or micropayments. (Transaction processing is automated, so it does not rely on expensive transaction channels such as checks, and the costs of transactions are independent of the amount paid.)

Criterion 5: Convertibility of Funds in the System. A user is able to withdraw money from the system to their check account or to request a check: "You can withdraw funds from your PayPal account by requesting an electronic funds transfer to your bank account or by requesting that a check be sent to you by U.S. mail … . Your money should become available within 3-4 business days … . You will receive an automatic email acknowledgement every time you make a request to withdraw funds" (https://www.paypal.com/cgi-bin/helpweb?cmd=_help). PayPal supports multiple-currency transactions. By the end of 2003 the Multiple Currencies feature of PayPal included "the ability to send and receive PayPal payments in Canadian Dollars, Euros, Pounds Sterling, or Yen, as well as U.S. Dollars" (https://www.paypal.com/cgi-bin/helpweb?cmd=_help). PayPal supports multiple-currency transactions. By the end of 2003 t).

Criterion 6: Accessibility for New Users/Help Facilities**.** PayPal has a well-designed help facility that describes the system in great detail, addressing

both new and experienced users. For instance, the relevant help section provides explanations of the measures used to ensure security. Availability of such information can be critical for enabling potential customers to decide whether they should use the system for payments (Rauterberg, 1995).

Criterion 7: Interaction Design/Usability. The interaction design of PayPal resembles that of an E-Commerce site and adheres to established usability guidelines for this type of Web site (e.g., Nielsen, Molich, Snyder & Farell, 2000). For economy of space, we do not present a full evaluation of the usability of this Web site. In the version examined at the end of 2004, there were several ways in which the usability could be improved, for example, by making the amount of money sent more prominent, by making the language simpler and more "conversational," and by marking the button effecting the payment clearly as "Send." Overall, one could think of PayPal as having adequate usability for its purpose, though several minor changes could help improve usability further.

Criterion 8: Interoperability of the System With Other Payment Technologies. PayPal scores well on interoperability with other payment technologies. The downside of this is that numerous perpetrators of fraud with stolen credit card information and identifications have used PayPal as a "money-laundering" system to profit from the situation that the card does not have to be presented.

4. DIARY STUDY: A QUALITATIVE INVESTIGATION OF USER EXPERIENCES WITH EPS

Researchers investigating user behavior during E-Commerce activities face a substantial challenge arising from the sensitive nature of payments and money. Expressions of user attitudes are known to be poor predictors of behavior, particularly when a large number of situational factors influence this user behavior (Aizen & Fishbein, 2005). For payments, this is accentuated as was illustrated with the examples analyzed in the previous sections. Another difficulty is that when people deal with money in real life, their behavior is likely to differ drastically from that during simulated money transactions in the context of a laboratory experiment. To overcome these challenges, a diary study was conducted; this study aimed to uncover problems and positive experiences of users with EPSs during actual use and to understand what functionality they need for payments and how this should be presented to them (Abrazhevich & Markopoulos, 2002).

The study concerned five online EPSs. These are (a) "Internet Bankieren" (Postbank); (b) "Internet Bankieren" (ABN-AMRO); (c) "Electronic Banking" (ABN-AMRO), the older version of Internet Bankieren; (d) "Direct Betalen" (Rabobank); and (e) PayPal. The first four systems are components of electronic banking systems of reputable Dutch banks. In addition to electronic payments, they support many other functions such as investments, sav-

ings, and other banking products. PayPal was chosen as a representative of a purely Internet online EPS; it neither is part of a banking system nor was founded by a "traditional" and established financial institution. From this viewpoint, this system provided an interesting contrast with the bank-supported payment systems.

4.1. Participants

Ten participants were recruited by means of e-mail and poster advertisements, distributed at our university campus. Priority was given to finding a small set of participants who would be committed to filling in diaries for several weeks and who would be using EPSs for actual payments in a B2C context rather than just managing personal finances. Among the 10 participants, 4 were students of various departments, 4 were educational employees, and 2 were administrative workers. Five participants described themselves as experts in online activities, whereas 5 were at an intermediate level of Internet experience as measured with appropriate excerpts from the questionnaire used for the GVU (1998) World Wide Web User Survey. Four participants had moderate computer experience; the other 6 had a high level of computer experience, as measured by the relevant questionnaire by Mayhew (1999). (For more details, see Abrazhevich, 2004.)

4.2. Process and Materials

The diary was given to the participants in a briefing session where the purpose of the study and the use of the data they would provide were explained, and informed consent was obtained. General information about the participants was also collected regarding demographics and experience with the Internet and payment systems. The diary consisted of several sections: instructions, a separate section where a number of open questions was asked about each payment, and a blank space for writing the diary notes. Participants were asked to fill in the provided forms after every transaction, mentioning their problems, opinions, observations, and expectations of interaction with the system in question. They were asked to record payments to online shops and payments of bills and services. Payments to friends and relatives, or mere money transfers between accounts, were excluded because of the focus of this research on B2C E-Commerce, and users were asked not to enter them in the diary. Diary items asked participants to express their impressions of privacy, trust, security, and usability. A debriefing interview lasting about 60 min was conducted after the diary had been completed, and this provided us with more elaborate comments and clarifications. Notes were taken during the interviews, which were taped and transcribed for later analysis.

4.3. Diary Study Results

The periods covered by the diary study ranged from 4 to 6 weeks. The participants, taken together, performed more than 30 payment transactions. (This is a small number, but it has to be kept in mind that these were non professional users of payment systems.) They reported more than 70 problems in total (aspects of the interaction they did not like or with which they experienced difficulty) and positive findings (aspects they liked or considered successful, etc.). The aspects most frequently mentioned were that the participants trust the bank they use and that the banks do not ask for too much personal information because they already have client relationships with the participants. Analyzing the execution of the diary study, it has to be noted that the participants were fairly punctual in filling in the diaries. They accurately reported the desired number of payments and were open and willing to go into details during the debriefing interviews. The in-depth interviews did not uncover any discrepancies with the diary records. In all, a substantial amount of qualitative data was available for analysis.

The data (diary entries, notes from interviews, and interview transcripts) were analyzed following the open coding and selective coding procedures described by Strauss and Corbin (1990). The analysis identified 36 generic problem descriptions and causal explanations regarding the interaction design of the systems used. Some examples of the problems identified are summarized next.

- Informants complained about usability aspects of the payment systems, especially with regard to the registration process. Some of the security measures used (long passwords, security questions, 1-hr-long registration/installation process, multiple security codes) were found "excessive" and "annoying," and even prevented 2 participants from completing the registration.
- Inconsistency of online forms in comparison with the previous experience of the participants (e.g., different order of filling in information compared with the paper form). One payer could still not get accustomed to the electronic payment form, even after having used it for several months prior to the study.
- Some participants were worried that third parties could get access to their personal information or their money, but despite this worry they use the system. Others felt that their money is safe, but the personal information is not, and can be revealed to third parties in one way or another.
- Two participants using PayPal were apprehensive about security risks.

- One participant did not like having to reveal her nationality and e-mail address, which was asked of her during the registration procedure; she felt these questions threatened her privacy.

Positive reports concerned the speed and efficiency of using Internet-based payment, the ability to schedule payments, and the trust toward the banking institutions behind the online payment systems.

5. DESIGN GUIDELINES

Following the studies just described, it was important to summarize design recommendations in an operational form that could be applied by payment system designers. A set of 12 design guidelines (DGs) was proposed. These guidelines are described using an adaptation of the templates by Smith and Mosier (1986) and ISO 9241 (ISO, 1996) for presenting user interface design guidelines. Each DG has a title, a high-level definition, and a detailed description that includes operational recommendations listed as bullet points. A "general problem part" depicts the issues addressed by this DG template. A DG template concludes with comments by an external expert in developing EPSs and payment products that were obtained as part of the validation exercise discussed in the next section. Figure 1 presents an example in the form of the template for DG1 on "security policy." The detailed descriptions of all DGs can be found in Abrazhevich (2004). Figure 2 presents a summary of these design guidelines.

So far, no such set of guidelines has been published for the design of EPSs. There is some overlap with general guidelines for designing E-Commerce Web sites. For instance, a Nielsen-Norman Group report suggests similar guidelines on privacy, costs, and trust transference (Nielsen et al., 2000). Their guidelines ("Build on the trust customers have for existing merchants and brands" and "Link to reputable independent sources") overlap with DG6 on trust transference. Guidelines on "Fair Pricing" (e.g. "Show total cost, as soon as possible" and "Justify prices that appear odd") partially overlap with DG4 on control over the costs of the use of the EPS. The guidelines defined in the Nielsen-Norman Group report are widely applied as state of the art practice for the design of E-Commerce Web sites; however, no empirical research to demonstrate their adequacy has been published.

The DGs listed in Figure 2 address issues that are specific to payment systems but that are not covered by the guideline sets for E-Commerce mentioned already. For example, DG5, DG7, DG8, DG9, DG10, and DG12 are new and specific to the design of online EPSs. Concluding, these DGs are potentially a valuable and concrete contribution to the design of online EPSs, if their added value can be confirmed through their application.

Figure 1. **Structured description of DG1 on security policy "Inform users about security measures and provide a security policy."**

DG1. Inform users about security measures, and provide a security policy.

Security policy: the existence and strength of security measures used in the payment system to protect users should be clearly explained to the users. This can be done by providing information in e.g. a paper manual or online help, or by dedicating a part of the website to the security policy.

Provide clear visibility of the security measures employed. This can be done by describing which security measures and technology have been implemented.

Explain why the system is secure for transactions.

Provide customer support (online or telephone) on security-related issues.

Supply regular information updates on changes and upgrades in security and the security policy; show the date of the latest update.

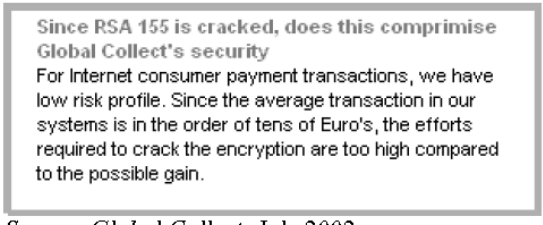
Address security issues specific to 1) a single payment (e.g. communicate the security of transactions to the users), and to 2) the operation of the system in general (e.g. provide the capability of deactivating passwords or blocking accounts offline by phone).

If using services or technology from reputed security institutions or companies, inform the users about this cooperation, e.g. demonstrate security seals or logos of the security organisations.

Explain which security measures are employed for information management and storage, provided that such information will not compromise security.

Do not try to cheat hackers by providing wrong and misleading information - hackers will know the real situation via different means, The potential harm of misinforming the users may be inestimable for the reputation.

Example: Global Collect provides textual information in a dedicated help section describing which security solutions and measures have been implemented. It explains why the system is secure for transactions.



Source: Global Collect, July 2002.

Expert comments

The comments below are by the expert consultant of the Postbank Department of New Business Technology:

'This design guideline is testable by showing two different product brochures or websites (from accepting sellers).

In our test we have used:

Our trusted brand,

Brochure with information,

No [security] signs, logos.'

Figure 2. **Initial Set of Design Guidelines.**

DG1	Inform users about security measures and provide a security policy.
DG2	Explain what types and details of personal information are to be retained, why, and how they will be used.
DG3	Provide clear and explicit policy on privacy, and make it noticeable to users.
DG4	Give users control over the costs of using the payment system.
DG5	Allow users to control critical actions and information.
DG6	Seek reputation and trust transference from reputed partners and technology providers, and communicate trust transference to users.
DG7	Take measures to address risks, and inform users about these measures.
DG8	Ensure that interaction with the payment system resembles users' expectations about the payment process.
DG9	Provide features for automating payments.
DG10	Provide usable authentication.
DG11	Interfaces should be presented in a clear logical and understandable way.
DG12	Provide features of customization of payment environments.

6. BANKLIJN CASE STUDY: APPLICATION AND EVALUATION OF THE DESIGN GUIDELINES

To verify the claim that the proposed DGs can actually benefit the design of online EPSs and possibly enhance their acceptance by end-users, a confirmation case study was conducted regarding the redesign of an existing payment system and the comparative evaluation of the original and the redesigned versions (Rauterberg, 1991). An existing commercial payment system was evaluated against our set of hypothesized DGs. A number of changes were made to the old system where it failed to meet the DGs, or did not meet them sufficiently. Thus a new version of the system was created, implementing the relevant changes. The two versions of the EPS were compared on the basis of user attitudes, measured by means of the questionnaire developed for this purpose. The differences between the two systems were analyzed statistically. In the sections below we describe this evaluation study in more detail.

6.1 The System Under Test

The case under study was the "Postbank Betaallijn" (the Postbank Payment Line). At the time our study was proposed the system had not undergone rigorous user testing. After initiating payment orders on a seller's Web site, users interacted with both versions and authorized payments by telephone. From the user viewpoint, the system consisted of two parts, the Payphone Betaallijn and the Postbank Betaallijn. When making telephone calls, the users are first connected to the Payphone part of the system, where they can manage and

confirm their orders. After the initial confirmation, the users are connected, within the same telephone call, to the Postbank's part of the system, where they can actually authorize payments.

The generic process of purchasing on the Internet with the Betaallijn works as follows.

- After selecting the products to be bought at an online shopping Web site, the customer enters his telephone number at the "checkout" of the seller's Web site. This checkout is essentially an online form where the payer enters the order and payment details and confirms the payment by submitting the form to the seller's Web site (by pressing the button "confirm payment").
- Then the customer dials the Betaallijn from the same telephone entered already at the seller's site. The customer is greeted by Payphone's part of the system. The customer's telephone number is recognized by the system, and the corresponding amount(s) for the purchases made at the Web site is/are spoken back to the customer.
- The customer interacts with the payment system via a fully automated Interactive Voice Response System. The customer selects options on a voice menu by pressing buttons on the phone that correspond to the menu options.
- After a confirmation of the order, the customer is put through to Postbank's part of the system. By entering his or her Postbank account number and the password of the Betaallijn system, the payer gives authorization to actually carry out the payment.
- If the payment is completed successfully, the confirmation of the payment is played back to the customer, describing the details of the effected payment.

For example, let us suppose that a user wants to order a wall poster for 14.95 from the Web site Posters.nl. The user proceeds to the checkout, enters his or her fixed or mobile telephone number on the Web site (e.g., 0401234567), confirms the payment, and calls the Betaallijn number (0201234567) from the telephone with the telephone number he or she has entered on the Web site (0401234567). The user will be connected to the first part of the dialogue system, Payphone IVR. The dialogue for one payment using the old system version (i.e., before the application of the design guidelines) would be of the following form, where S = the System's voice menu playback and U = User action:

S: "Welcome to the Payphone Betaallijn system for the payment of your order."

"We have an order for you for the amount of 14 euros 95 cents from Posters.nl."
"To pay press 1, to repeat press 4, to cancel press 9."
U: [By pressing 1 the user is connected to the Postbank Betaallijn IVR.]
S: "One moment please, we are transferring you to the Postbank Betaallijn."
"Welcome to the Postbank Betaallijn."
"Please enter your Postbank account number."
U: [The user enters the account number.]
S: "Enter your PIN code."
U: [The user enters the PIN code.]
S: "After your confirmation the payment will be immediately processed and transferred to Posters.nl. To authorize the payment of the amount of 1Euros 95 Cents to Posters.nl press 1, to cancel the payment press 9."
U: [The user presses 1.]
S: "Your payment is being processed, one moment please."
<Beep> "Your payment has been processed successfully. Thank you for your payment."
U: [The user is transferred back to the first voice menu system of the Payphone Betaallijn.]
S: "Welcome back to Payphone Betaallijn system. Your payment has been received. Thank you for your payment. There are no more orders for you. The connection will now be terminated."
U: [At this point the user hangs up.]

The Web shop receives the confirmation of the payment from Postbank and ships the goods. The amount is immediately deducted from the user's Postbank account.

6.2. Expert Review of the Design Guidelines

An expert designer of payment systems who is responsible for the development of the Postbank Betaallijn was asked to apply our design guidelines to this system and to suggest concrete design improvements. We also asked for his opinion of the usefulness of the guidelines provided. Because the reaction of only one expert was obtained, the agreement of other experts cannot be assumed.

The expert found that it was possible to evaluate their old system against most of our DGs. In particular, the expert concluded that DG1, DG4, DG5, DG6, DG7, and DG8 were applicable and that the old system already complied with these DGs in one way or another. DG2 "personal information" and DG3 "privacy policy" were considered applicable, though the Betaallijn did not comply with the guidelines because the old system was still at the test stage and not yet released. The expert questioned the feasibility of evaluating DG10 on authentication and argued that their password policy was already

an established "model used for years." The usefulness and correctness of DG10 itself was not doubted.

According to the expert, DG9 "automation of payments" was beyond the scope of the intended functionality of the new system and is more related to the domain of electronic banking than to the user interface of an online EPS. Our diary study has nevertheless clearly demonstrated that automated payments may be beneficial to users of online EPSs, so this guideline was retained for the design of the new system. The expert also considered DG11 and DG12 as very important but believed that the Betaallijn system already satisfied them, no direct improvements to the system could be proposed.

Based on the design guidelines, the expert proposed changes that were implemented in a revised version of the Postbank Betaalijn. All changes were agreed with the first author, and they were the only changes made to the system. In the rest of this article, the initial version of the system is called "old system," and the redesigned version is called "new system." Applying DG11 and DG12 did not prompt any changes to the system. The changes effected are listed per guideline in Figure 3.

DG1: *Inform users about security measures and provide a security policy. [See also DG7]* A security policy was introduced in the new system, and this policy was clearly communicated in the interface

DG2: *Explain what types and details of personal information are to be retained, why, and how they will be use.* The privacy policy in the new system explained how personal details will be used.

DG3: *Provide a clear and explicit policy on privacy, and make it known to users.* An extended privacy policy was introduced in the new system. Links to the privacy policy were added to the payment Web pages in the new system.

DG4: *Give users control over the costs of the use of the payment system.* Users of the new system are informed that they are calling a free number when they connect to the Betaallijn.

DG5: *Allow users to control critical actions and information*. The ability for users to block their password (e.g., because someone else has gotten to know it) via the interactive voice menu was introduced in the new system. This enables users to call the system access number, navigate the interactive voice menu by pressing keypad buttons suggested by the voice prompts, and block the password after confirming the desired action.

DG6: *Seek reputation and trust transference from reputed partners and technology providers, and communicate trust transference to users*. The Postbank logo was displayed on the Web site for the new system.

DG7: *Take measures to address risks, and inform users about these measures. [See also DG1]* Potential risks were addressed in the security policy of the new system. Functionality to block Betaliijn passwords was introduced.

Figure 3. **Changes Made to the System, the Corresponding Design Guidelines, the Tasks Designed to Test These Changes, and the Dependent Measures.**

DGs	Old System	New System	Task	Measure
DG1. Security policy for security measures	Absent or minimal	Added and Present	1–5 4	RM2 SM4
DG2. Privacy policy at payment site	Absent	Made known on the payment page	1–5	RM3
DG3. Privacy policy at bank site	Standard Postbank style	Made known on the Postbank website	1	SM1
DG4. Costs	Paid number notification	Free number notification	3 5	SM15 SM16, SM17
DG5. Control of critical actions and information	Via customer service only	Blocking passwords via the system	2	SM3
DG6. Trust transfer	No (Postbank) logos on the payment page	Postbank logos are present on the payment page	5	SM7
DG7. Security policy for risk taking	Absent or minimal	Added and Present	1–5 2	RM1 SM2
DG8. Interaction design and Help means	Standard	Enhanced plus help information.	1–5 5	RM4–RM10 SM8
DG9. Scheduled payments	No	Yes	3	SM9–SM11
DG9. Batch payments	No	Yes	5	SM12–SM14
DG10. Password length	6	4	5	SM6
DG10. Authentication	3 steps	2 steps	5	SM5

Note. See Section 6.9 for more details. RM = repeated measure; SM = specific measure.

DG8: *Ensure that interaction with the payment system resembles users' expectations about the payment process.* This design guideline presupposes that the interaction process could be presented to users in a familiar way. In this respect, the Betaallijn is similar to the existing Postbank telephone banking system. It was hoped that the aforementioned changes introduced by the DGs would result in a better interaction design and improved usability of the redesigned system. For users for whom the operation of the system is not intuitive, a more detailed explanation of how the new system operates was provided in the online help and as a paper brochure.

DG9: *Provide features for automating payments.* A function for multiple (batch) payments was implemented to allow users to make several payments

with one authorization. A function for scheduled payments was implemented to allow users to set a future date for effecting payments.

DG10: *Provide usable authentication.* The password length was changed: The PIN code for authorization was reduced from six to four digits in the new system. The authentication process was made simpler: The number of confirmations of a payment was reduced from three to two steps in the new system.

6.3. Experimental Evaluation of the Design Guidelines

A laboratory experiment was set up in which participants had to use the two systems to pay for a few online purchases. The two systems were compared in terms of user attitudes (measured by means of the questionnaire developed for this purpose). The differences between the two systems were analyzed statistically.

Our main hypothesis suggests that the application of our design guidelines will result in a difference in the attitude of users towards the two versions of the system.

6.4. Participants

The 46 participants were recruited by the Postbank call center from among the bank's clients who were already familiar with the existing Postbank EPSs (e.g. Girofoon, Girotel). All participants had a good understanding of English. In general, both samples were well balanced in representing most user categories. Within the constraints of availability and scheduling the participants were divided into two groups attempting to balance them with respect to the demographic variables: age, gender, experience with Internet payment systems, yearly income, and computer experience. Twenty-five participants used the old system, and 21 used the new system.

6.5. Tasks

Participants were provided with a short (10-min) introduction to the system. They were told that Betaallijn is a Postbank system for Internet payments that allows them to make payments online via a Postbank bank account. Participants were informed that the study was aimed at understanding their attitudes, opinions, impressions, and feelings about Betaallijn. Participants were given the following instructions regarding their test tasks:

Task 1**.** Please browse Posters.nl Web site, select and pay for an item that you would like to purchase.

Task 2**.** Suppose you suspect that the PIN-code (payment code) of your account has been stolen. Please find the best way to block your payment code, so that no one else can use it anymore.

Task 3**.** Suppose you have to pay rent for your house for a certain period of time. Please find the best way to arrange to pay rent of 100 per month for 2 months (e.g. April and May). The rent has to be paid on the first day of the month, and should not be paid in one payment, but for each month separately.

Task 4**.** Suppose that the PIN code of your account has been blocked and you would like to reactivate it. Please find out what would be the best way to reactivate the account. [*Note.* The users were asked only to find out how to do the task without actually doing so, since the reactivation of the test account would have required a physical or postal communication with customer service, which could not be simulated meaningfully in our experiment.]

Task 5**.** Suppose that you have to make 3 or 4 payments. Please go to *Posters.nl* website, and select 3 or 4 items to purchase. Pay for these items in a way you think is the quickest and most efficient.

Although participants could not be assumed to be interested in spending their participant fee to purchase posters, the realism of the task allows us to assume that they were interested in carefully and correctly executing the payment itself, so the payment was real as far as they were concerned. Note, that eventually no amount of money was deducted from their participant fee.

6.6. Procedure

During the introduction, a couple of examples were given to illustrate how Betaallijn works. Participants were told how to select products and how to make payments at the Web site, and they were instructed on how to use the telephone. The users of the old system called the Betaallijn from the laboratory telephone and were informed by the system that they were calling a paid number. They had been told by the experimenter in advance that the connection costs would be deducted from their participation fee to encourage them to think of the number as a paid one and to make them as cost-conscious as for real-life payments. (No costs were actually deducted after the experiment.)

The participants were shown the Postbank Betaallijn Web site and given a paper brochure describing how the system works. This information was available for the participants if needed, but they were not obliged to read it beforehand. In this way we intended to emulate a real-life situation, for example, at home, where the users would refer to help only in the case of problems.

The participants were given the tasks and questionnaires in paper form and were instructed to fill in parts of the questionnaire after every task. They

were allowed to ask questions whenever they could not proceed; however, they were encouraged to find a solution on their own first. The experimenter communicated with the participants from the control room via an intercom system whenever it was necessary. This setup minimized the possible influence on participants by the presence of the experimenter in the laboratory during the experiment. Participants who got confused or stuck were given about 5 min to find a solution (see "Socratic Dialog," Rauterberg, 1991). Then a general high-level hint was given to them, for example, where to look at the Web site on their own, or what they could try to continue the task. If this did not help, they were finally given detailed instructions on how they could solve the problem. If the participants attempted to start filling in the questions before completing the task, for example, not making enough or any attempts to complete the task, the experimenter would ask them why they did not perform the task first. If necessary, they were given a hint on how to proceed and asked to finish the task.

6.7. Experimental Setup

As the new system was not in full deployment yet, the evaluation could not include actual payments. To make the payment experience as real as possible, a limited form of deception was used, which was disclosed postevaluation to the participants. We created a working copy of a commercial Web site for selling wall posters. Participants were requested to use the Betaallijn to purchase goods on this site; they were not told that the test Web site was just a copy of the real one. The participants used a Postbank account for transferring real money, although no real transfer of money was actually performed in our experiment. This was not disclosed to the participants until after the experiment. Participants were told that they could use their participation fee for online shopping; all costs incurred during the transaction would be deducted from their fee. All transactions were realistic in that they were experienced exactly as they would be during the actual use of the system. The tests were conducted at a usability laboratory. The first author of this paper acted as the experimenter, that is, facilitating the process, receiving participants, introducing the system and the tasks, and keeping observation notes. During the tests he was seated behind a one-way mirror in a separate observation room.

Participants were encouraged to find the best way for them to carry out the tasks. They were advised to use the paper brochure that was given to them and the online help if necessary, but they were not obliged to do so. After each task they were required to fill in a questionnaire (discussed next) that assessed their attitudes toward the system. When they had finished, the participants were interviewed about their experience and were invited to comment freely about the system. At the end they were given the full participation fee of

10 Euros. It took participants from 56 to 140 min to complete the five tasks. Participants' interactions with the system were video-recorded. The videos were reviewed later and used to verify and extend the notes taken during the interviews.

6.8. Experimental Design

A mixed experimental design was followed, with "System version" as the independent between-subjects factor and "Task" as the independent within-subjects factor. The mixed experimental design can be described as A × (B), where A is the system version and B is the task factor. It is a 2 × 5 design, where the repeated factor has five levels corresponding to the five specified tasks (Maxwell & Delaney, 2000). One of the reasons for choosing a between-subjects design is that it was not possible to run two versions of the system at the same time; after the first group of participants had tested the old version, the test setting had to be changed into the new version to continue the experiment with the second group. The test participants were randomly allocated to one of the two test conditions.

6.9. Measures

As dependent variables there were a number of repeated measures (RMx; see Figure 4) taken after all tasks; and some task-specific measures (SMx; see Figure 5) to measure only specific aspects of the particular task.

Users' attitudes and opinions about aspects of the payment system under test were measured by means of a questionnaire (for more details, see Abrazhevich, 2004). To assess whether the application of the design guidelines achieved the desired effect, we compiled a questionnaire from existing standard instruments to assess the payment system.

The questions for assessing the usability of the system are a subset of the SUS questionnaire (Brooke, 1996). Questions on "perceived usefulness" and "perceived ease of use" were adapted from Davis (1989). These questionnaires are validated tools that have been shown to be reliable and are widely used (Perlman, 2009). In addition, they are both quite short and generic, which helped to create a concise questionnaire. Answers to the questions were measured by semantic differential scales (e.g., the perceived safety of payments was assessed on a scale with the extremes *completely unprotected* to *completely protected*). Bipolar questions had values ranging from –3 to +3; monopolar questions had values from 1 to 7.

RM1 to RM10 as dependent measurements were RM1 "Trust in the system," RM2 "Safe to use the system," RM3 "How personal information is protected," RM4 "Would use the system frequently," RM5 "Ease of use," RM6

Figure 4. **Repeated Measures Results.**

Repeated Measure and Scale Used	Task System	1		2		3		4		5		Total	
		Old	New	Old	New	Old	New	Old	New	Old	New	Old	New
1. "How high would you rate your trust in the system at this moment?"	*M*	4.76	5.29	4.95	5.43	4.14	5.05	4.62	5.29	4.38	5.24	4.57	5.26*
	SD	1.64	.96	1.28	.81	1.82	1.24	1.28	.90	1.69	1.09		
(1 = *very low*, 7 = *very high*)	*N*	21	21	21	21	21	21	21	21	21	21	21	21
2. "Do you feel it would be safe to make transactions with your money using this system?"	*M*	0.81	1.57	1.19	1.90	0.52	1.33	0.71	1.29	0.86	1.52	0.82	1.52*
	SD	1.78	0.87	1.29	0.83	1.78	1.35	1.68	1.06	1.42	0.93		
(–3 = *completely unsafe*, +3 = *completely safe*)	*N*	21	21	21	21	21	21	21	21	21	21	21	21
3. "Do you feel your personal information is sufficiently protected in this system?"	*M*	4.45	5.18	4.95	5.59	4.65	5.53	4.70	5.35	5.05	5.47	4.76	5.42*
	SD	1.64	1.01	1.39	1.06	1.76	0.72	1.34	0.86	1.05	0.80		
(monopolar scale: 1 = *completely unprotected*, 7 = *completely protected*)	*N*	20	17	20	17	20	17	20	17	20	17	21	17
4. "I think I would like to use this system frequently (often)."	*M*	0.35	1.13	.39	1.27	–.48	0.80	0.17	1.00	–.13	1.00	0.06	1.04*
	SD	1.85	1.06	1.80	0.80	1.90	1.15	1.83	1.13	2.01	1.00		
(bipolar scale: –3 = *strongly disagree*, +3 = *strongly agree*)	*N*	23	15	23	15	23	15	23	15	23	15	23	15
5. "I think the system is easy to use"	*M*	2.37	2.24	2.42	1.65	2.16	.88	2.16	2.00	1.89	1.29	2.20	1.61*
	SD	0.76	0.75	0.61	1.50	1.07	1.87	1.01	1.17	1.29	1.86		
(bipolar scale: –3 = *strongly disagree*, +3 = *strongly agree*)	*N*	19	17	19	17	19	17	19	17	19	17	19	17

(continued)

Figure 4. **(*Continued*)**

Repeated Measure and Scale Used	Task System	1		2		3		4		5		Total	
		Old	New	Old	New	Old	New	Old	New	Old	New	Old	New
6. "I find the system complex"	*M*	–2.04	–2.05	–1.91	–1.30	–1.09	–.70	–1.78	–1.75	–1.00	–.60	–1.56	–1.28†
	SD	1.11	1.00	1.70	1.78	1.98	2.08	1.54	1.68	2.11	1.98		
(bipolar scale: –3 = *strongly disagree*, +3 = *strongly agree*)	*N*	23	20	23	20	23	20	23	20	23	20	23	20
7. "I find the various functions in this system are well integrated"	*M*	1.00	0.65	1.16	0.88	0.11	0.29	0.68	0.76	0.05	0.12	0.60	0.54†
	SD	1.56	1.46	1.30	1.69	2.03	1.45	1.34	1.30	1.72	1.58		
(bipolar scale: –3 = *strongly disagree*, +3 = *strongly agree*)	*N*	19	17	19	17	19	17	19	17	19	17	19	17
8. "I feel very confident using the system"	*M*	1.25	1.39	1.25	1.06	0.46	0.39	1.17	1.33	0.71	0.83	0.97	1.00†
	SD	1.94	1.09	1.75	1.43	1.91	1.75	1.49	1.37	1.73	1.34		
(bipolar scale: –3 = *strongly disagree*, +3 = *strongly agree*)	*N*	24	18	24	18	24	18	24	18	24	18	24	18
9. "I needed to learn a lot of things before I could get going with this system"	*M*	–2.04	–2.40	–2.08	–1.90	–1.46	–1.70	–1.92	–1.80	–1.83	–1.15	–1.87	–1.79†
	SD	1.63	1.10	1.47	1.83	1.72	1.78	1.67	1.61	1.74	1.95		
(bipolar scale: –3 = *strongly disagree*, +3 = *strongly agree*)	*N*	24	20	24	20	24	20	24	20	24	20	24	20
10. "The help instructions on the web page and in the brochure were useful for the task"	*M*	1.57	1.22	1.81	1.67	0.24	0.44	1.48	1.61	0.57	0.56	1.13	1.10†
	SD	1.08	1.31	1.44	1.41	1.90	1.58	1.44	1.54	1.57	1.50		
(bipolar scale: –3 = *strongly disagree*, +3 = *strongly agree*)	*N*	21	18	21	18	21	18	21	18	21	18	21	18

*$p = .05$. **$p = .01$. †*ns.*

Figure 5. **Results of Task-Specific Tests.**

Dependent Variable	System Version	*N*	*M*	*SD*	*df*	*F*	*p*
SM1. Are you comfortable with using personal information with the system•	Old	24	4.79	1.91	1, 42	5.106	.029*
	New	20	5.85	0.93			
SM2. How does the information provided over security measures influence your trust in the system • •	Old	24	0.33	1.52	1, 43	4.389	.042*
	New	21	1.14	0.96			
SM3. How far does the ability to block the payment code give you a feeling of control over the situation? • •	Old	25	1.04	1.56	1, 44	5.161	.028*
	New	21	1.90	0.83			
SM4. Does it feel safe to use the system? •	Old	22	4.64	1.49	1, 39	5.067	.030*
	New	19	5.58	1.12			
SM5. Are you comfortable with the way you have to identify yourself to the system? •	Old	25	0.52	1.96	1, 43	5.451	.024*
	New	21	1.05	1.19			
SM6. Do you think the length of the payment code is appropriate? • •	Old	24	–-0.33	0.70	1, 43	6.795	.013*
	New	21	0.24	0.76			
SM7. The Postbank brand influences trust? • •	Old	23	1.52	0.94	1, 41	4.650	.037*
	New	20	2.10	.078			
SM8. Would you be likely to use the system for your Internet payments in the future? • •	Old	25	–0.12	1.98	1, 43	7.363	.010**
	New	20	1.30	1.38			
SM9. *What is your opinion of the way in which you had to make these rent payments?* (1= 'very slow', 7= 'very fast') •	Old	25	2.28	1.76	1, 44	4.169	.047*
	New	21	3.38	1.88			
SM10. *What is your opinion of the way in which you had to make these rent payments?* (-3= 'rather useless function', +3= 'very useful function') • •	Old	24	–0.71	1.87	1, 42	5.100	.002**
	New	20	1.11	1.66			
SM11. *What is your opinion of the way in which you had to make these rent payments?* (-3= 'very difficult', +3= 'very easy') •	Old	24	4.54	2.10	1,42	.096	.758†
	New	20	4.35	1.95			
SM12. *"What is your opinion of the way in which you had to make these multiple payments?* (-3= 'rather useless function', +3= 'very useful function') • •	Old	23	–0.35	1.96	1, 41	5.55	.023*
	New	20	0.90	1.41			
SM13. *What is your opinion of the way in which you had to make these multiple payments?* (-3='very hard', +3='very easy') • •	Old	22	–0.34	2.17	1, 39	.165	.687†
	New	19	0.90	1.70			
SM14. *What is your opinion of the way in which you had to make these multiple payments?* (1= 'very slow', 7= 'very fast') •	Old	23	1.52	1.85	1, 41	.089	.767†
	New	20	2.10	1.97			
SM15. How much would you be prepared to pay for the call? •	Old	23	2.22	1.08	1, 41	.045	.833†
	New	20	2.15	0.98			
SM16. Do you feel that the costs for paying the call are appropriate? •	Old	25	3.68	1.77	1, 44	.675	.416†
	New	21	3.24	1.86			
SM17. Do you feel you would be in control of the costs of using the Betaallijn? •	Old	25	3.80	1.75	1, 43	.225	.638†
	New	20	4.05	1.76			

Note. • = monopolar scale [1…7]; • • = bipolar scale [–3…0…+3])
*p = .05. **p = .01. †*ns.*

"Found the system complex," RM7 "System's functions are well integrated," RM8 "Felt confident using the system," RM9 "Needed to learn a lot of things before using the system," RM10 "The help instructions on the web page and in the brochure were useful for the task."

SM1 to SM17 as dependent measures were taken after certain tasks; they were used to gauge user attitudes to the aspects of the systems specific to a particular task. Figure 3 describes how the design guidelines map to the tasks and measures that are intended to test the desired effect of the design guidelines that were applied.

6.10. Results and Analysis

Results: Repeated Measures

This section presents the most interesting results of only the RMs; in the next section, Discussion, we present our interpretation of these results in relation to our DGs. To analyze the differences between the two systems, a general linear model analysis of variance (ANOVA) for RMs was performed (SPSS version 12.01 for PC). Figure 4 presents these results. The number of answers (N) varies for different measures, because of the cases where the participants opted for the "don't know" answer (excluded from the analysis as missing values).

As hypothesized a significant main effect was found for the factor "system" in favor of the new system for the repeated measures RM1 regarding trust, RM2 about feeling safe to transact, RM3 that information is protected sufficiently, RM4 about intention to use, and RM10 regarding the quality of help.

There was a significant effect in favor of the old system rather than the new one regarding RM5, the ease of use.

No significant differences were found regarding the old and the new system for the measures RM6 regarding the perceived complexity of the system, RM7 regarding functionality integration, RM8 regarding confidence to use the system, and RM9 learnability.

As could be expected, for all measures a significant main effect was found in the factor "task." However, we could not find overall any significant interaction effect between the two independent factors "system" and "task."

Results: Task-Specific Measures

After each task, SMs of user attitudes to aspects particular to this task were registered once. These measures were intended to evaluate users' attitudes about special aspects of the systems after each task; see Figure 3 for the mapping of the measures to the tasks. For these measurements, the two systems

were compared with a one-way ANOVA. The ANOVA was performed with user responses as the dependent variable and the system version as the between-subject factor. Several measures indicate significant differences between the two system versions. Figure 5 summarizes these results, listing means, levels of significance, and *F* statistics.

The new system fared significantly better than the old system for special measures: SM1 regarding how comfortable they felt to use personal information, SM2 regarding the influence of information on security upon the trust to the system, SM3 regarding the feeling of control that results from the ability to block codes, SM4 regarding how safe it feels to use the system, SM5 regarding the authentication procedure, SM7 concerning the influence of the brand upon trust, SM8 regarding intention to use, SM9 regarding the efficiency of scheduled payments, SM10 regarding the usefulness of the scheduled payment feature, and SM12 the usefulness of making batch payments.

The attitudes regarding the length of the payment code (SM6) differed significantly between the two systems. The "six-digit password" of the old system appears a bit too long ($M = -0.33$), whereas the "four-digit password" of the new system appears a little too short ($M = 0.24$).

No significant improvement was shown regarding SM11 the ease of making scheduled payments; SM13 the ease of use of making batch payments, probably because the task was easy in both cases; and SM14 the speed of making scheduled payments. SM15 posed the question, "How much would you be prepared to pay per minute for the call to Betaalljn?" (monopolar scale: 1 = "0 cent," 2 = "2–3 cents," 3 = "10–15 cents," 4 = "15–25 cents," 5 = "25–50 cents," 6 = "51 cents–1 Euro," 7 = "as much as I am asked"). There was no significant difference between the new system ($M = 2.15$) and the old one ($M = 2.22$) in the measurement of how much the users of both systems would be prepared to pay for the call. This seems reasonable considering the same functionality was offered in both cases and calls are cheap. Correspondingly SM16, regarding how reasonable participants found the costs, found no difference between the two versions, and no difference was found by SM17, regarding how much they felt in control of the costs for making payments.

6.11. Discussion of Design Guidelines

In this section we discuss how the findings of our experiment reflect upon the usefulness and adequacy of each design guideline. Figure 6 illustrates the relations between each DG and the outcome of the experimental measures (RM and SM). The findings regarding DG1–DG7 are described adequately in Figure 6; next, we examine more closely the remaining guidelines.

DG8. The participants would be more willing to use the new system than the old one (RM4 in Figure 4, SM8 in Figure 4); this increase in intention to

Figure 6. **Design Guidelines With Validation Status Based on the Experimental Results.**

Design Guideline	Experimental Result	Validation Status
DG1. Inform users about security measures and provide a security policy	RM2. It is "safer to use" the new system. SM4. "Safe to use the system" is rated higher in the new system.	Confirmed
DG2. Explain what type and details of personal information are to be retained, why, and how they will be used	RM3. Personal information is protected better in the new system.	Confirmed
DG3. Provide clear and explicit policy on privacy, and make sure that users are aware of it	SM1. More comfortable with using personal information in the new system.	Confirmed
DG4. Give users control over the costs of using the payment system	SM15, SM16, SM17. Measurement against validation: No significant difference between the systems in control over costs.	Not confirmed
DG5. Allow users to control critical actions and information	SM3. Ability to block the payment code gives more control over the situation in the new system.	Confirmed
DG6. Seek reputation and trust transference from reputed partners and technology providers, and inform users about such partnerships	SM7. The Postbank brand influences trust: higher in the new system.	Confirmed
DG7. Take measures to address risks and inform users about these measures	RM1. Trust in the new system is rated higher. SM2. Security information influences trust: higher in the new system.	Confirmed
DG8. Ensure that interaction with the payment system resembles users' expectations about the payments process	RM5. Measurement against validation: Ease of use is higher for the old system.	Not confirmed
DG9. Provide facilities for automatic payments	SM9. Speed of the multiple payments is perceived as higher in the new system. SM10, SM12. The usefulness of the scheduled payments is perceived as higher in the new system.	Confirmed
DG10. Well-designed authentication	SM5. Users are comfortable with the way they can identify themselves in the new system. SM6. The length of the payment code makes the difference between the two systems in favor of the new system.	Confirmed

use could be partially attributed to the improved interaction design in accordance with DG8. However, there is a contradictory result; despite the fact that the changes to the system were intended to improve its usability they did not create an observable improvement in the usability goal *ease of use* (RM5; Figure 4). The better rating for *ease of use* of the old system compared to the new one means that no claims can be made about the adequacy of this guideline.

DG9. Our experiment has demonstrated that the new feature of *multiple payments* brings benefits to users in terms of *speed* and *usefulness* (SM10 and SM12; Figure 5). This serves as evidence for validation of this guideline on automating payments. Regarding the other aspect of payment automation pertaining to scheduling payments, which was tested in the form of paying rent for a house, caution should be exercised when drawing conclusions about its contribution to the evaluation of this guideline. A proper execution of this task was supported only in the new system, whereas the participants using the old system had to repeatedly pay individual rent payments, and this was considered rather artificial by the participants who normally will not pay scheduled payments like rents in succession during one session. Some of the participants even refused to do the task, saying they would not pay rent in this way. Arguably, this experimental task favors the new system, which automated the task completely, whereas in the old system the task is not supported at all. Not surprisingly, participants reported high usefulness for this task in the new system (SM12; Figure 5).

On the other hand, scheduled payments have significantly decreased *ease of use* in the new system (RM5; see Task 3 in Figure 4). Possible reasons for this outcome are incorrect implementation of the task or the corresponding design guideline.

DG10. The difference in the length of the PIN code has underlined the importance of authentication, and suggests that a shorter four-digit *payment code* might be preferable to longer six-digit codes. This result, in combination with the observation that the participants were more comfortable with the *way they can identify themselves* in the new system (SM5 and SM6; Figure 5), supports the confirmation of this guideline concerning authentication.

It is however possible that the greater trust in the new system was a consequence of the whole complex of changes applied in accordance with the other guidelines. Taking into account a significant main effect for the difference between the tasks and the significance of the fourth order effect of the tasks factor in measuring trust in the system (RM1; Figure 4), participants scored Task 3 low on trust and Tasks 2 and 4 relatively high. Tasks 2 and 4 were focused mainly on the privacy and security policies and on the control over the critical information (DG1, DG2, DG3, and DG5). We conclude that these aspects were important in increasing trust and in alleviating risks for both systems.

The fact that the new system performed better in the *trust* measure than the old one gives added supporting evidence to the confirmation of DG1, DG2, DG3, and DG5.

In conclusion, the application of the design guidelines has resulted in the improvement of users' attitudes toward the new system relative to the old one and has raised the overall user acceptance for the redesigned system. The new system has scored higher than the old one in *trust* and *perceived usefulness*. The analysis of the results has indicated that the participants would be more likely to accept the new system. This is a good indicator of an overall positive influence of the set of design guidelines on user acceptance.

6.12. Limitations of the Experimental Study

When studying the use of design guidelines one always needs to address the problems that their adequacy and relevance have to be studied through their application to specific instances of the systems concerned and that their application is dependent on the interpretation of the designer who applies them. The extended descriptions of the design guidelines (which can be found in Abrazhevich, 2004) include a detailed operational description slightly more extensive than shown for DG1 in Figure 2. Our experiment could not attempt to confirm every detail of each DG as this poses several methodological and practical difficulties (see, e.g., Weir, Anderson, & Jack, 2006). Thus it may be argued that our findings (positive and negative) are predicated upon the way this one designer applied them. For example, advice advocating display of privacy statements does not detail what this policy should be and how it should be presented to users. The designer using the corresponding guideline relied on existing industrial practice, reference sources, and his own experience. It can also be argued that the results are predicated upon the specific system studied. Further studies involving more designers or applying the guidelines to different payment systems would help increase our confidence in the guidelines and improve them further.

The application of our set of guidelines as a whole has demonstrated an indisputable overall positive impact. The experimental results provide supporting evidence for the usefulness of DG1, DG2, DG3, DG5, DG6, DG7, DG9, and DG10. Further, the interpretation and adaptation to the problem at hand will always accompany the real-life application of design guidelines by practitioners, and this is why this validation case study can claim a high degree of ecological validity.

DG4 on control over the costs of using the payment system was not confirmed. A possible explanation might be that the issue of costs may be not as important as it seemed prior to the validation experiment, but this would conflict with other studies on the costs of electronic payments (Humphrey, Kim,

& Vale, 2001). Assuming that DG4 has a sound rationale, a possible reason for it not being confirmed could be that it was not implemented appropriately, or that this guideline is more relevant after sustained use of a system that was not evaluated in our experimental set up.

In most cases, the application of our DGs resulted in improvements in users' attitudes. For the few cases that this did not happen, simple explanations could be that there are inherent flaws in these DGs or that these DGs do not create an impact large enough to affect users' attitudes. Alternative explanations for not being able to confirm all DGs are discussed next.

Arguably, the old system was already well designed. A thorough design process preceding the first trials had already taken care of many crucial user concerns, and the creators of the system were quite proficient in their domain. It is hard to improve upon an already good system, which may be a reason for our guidelines not always resulting in significant improvements. For example, consider the result that there is no improvement in the usefulness of help in the new system. Both systems were evidently quite easy to understand because the participants did not need to consult the help facility. Thus, improvements made to the help system were not substantial enough to result in significant differences regarding how help was evaluated by participants.

Other negative results may reflect not necessarily on the design guidelines but on the details of its implementation. For example, it was not possible to record some of the new Payphone IVR voice menu items, as we did not have access to the voice of the person who had recorded the original items. Developers had to cut and paste the existing audio files to make new menu items. This workaround made some voice menu items sound a bit unnatural. This and other similar implementation problems may have resulted in the lack of statistically significant improvements in users' attitude and may even account for the lower rating of usability of the new system.

Although the whole experiment was set up to maximize ecological validity, there were still some limitations on how well the use and operation of the payment system could be simulated in a laboratory. For example, there was no customer support line, nor a fully fledged Web site for help and support that could be seamlessly integrated into the Postbank online help system. However, these limitations that are inherent in a laboratory experiment did not surface during the experiment sessions, so we argue that they do not compromise the validity of our findings.

From the original set of guidelines DG11 (on interaction design) is omitted. Although a clear usable interface is very important and we stand by the rationale for this guideline, the detailed advice it provides does not add to existing sets of guidelines for designing usable systems (e.g., see Nielsen, 1999). It is recommended that our set of guidelines should be used in conjunction with the guidelines proposed here that are specific to payment systems.

DG12 concerning customization was not found applicable by the designer during the evaluation study, who considered it outside the scope of his design problem. We believe, however, that this reflects more the organizational and business context that he operates rather than its importance to end-users. Therefore the guideline is maintained.

7. REVISED GUIDELINES FOR THE DESIGN OF ONLINE PAYMENT SYSTEMS

Based on the collection of studies reported, a set of 10 guidelines is put forward for which we consider ample evidence has been accrued regarding their positive impact upon user acceptance of payment systems. We describe them very briefly next, and we refer readers to Abrazhevich (2004) for a more extensive description:

1. Take measures to address risks (regarding safety, security, and privacy) and inform users making the measures taken visible, understandable, and justifiable.
2. Ask and use personal information parsimoniously, explaining what type of information will be retained, what it will be used for, and how it will be managed.
3. Provide a clear and explicitly privacy policy; make it known and understandable to users. Display privacy seals or announce compliance to related privacy legislation or codes of fair information practice.
4. Provide clear and complete explanation of costs associated with payments and use of the system; aim to lower or even eliminate these costs for the user.
5. Allow users to control critical actions and information: Provide flexible interaction sequence delaying commitment to the transaction until it is absolutely necessary. Allow users to block accounts off line or deactivate passwords.
6. Seek reputation and trust transference from reputed partners and technology providers and communicate trust transference to users; in practice this may mean informing users about partnerships and business relations with reputable partners.
7. Ensure that interaction with the payment system resembles users' expectations about the payment process. Designers should seek to understand users' mental model of the payment process, comply with the process applied by market leaders, avoiding frequent changes to how this process is implemented.
8. Support automation of payments: support scheduled payments and multiple, batch payments; support features such as personal address books or databases with payee information.

9. Provide usable authentication; limit the number of authentication steps to two if possible and avoid reauthentication prior to less significant operations, such as viewing account status.
10. Support customization of the payment system, for example, features for currency conversion, personalized message to go with payments, multiple logins for a group of people (e.g., family, organization, etc.).

8. CONTRIBUTION AND SUGGESTION FOR FUTURE WORK

Current practice regarding the interaction design of online EPSs is based mainly on ad hoc practices borrowed from the domain of banking or on general methods for Web design (e.g., Nielsen, 1999). Until now there has been no empirically based design advice for designers of online EPSs. This article contributes to this field a set of guidelines based on extensive empirical studies. The resulting guidelines do not substitute for general usability guidelines, principles, or heuristics but complement them to take into account user concerns specific to Internet-based payment systems.

An interesting avenue for future work that would complement our results would be to model the impact of individual factors on the user acceptance of EPSs. This could lead to the development of validated instruments for predicting the user acceptance of EPSs, encompassing concerns such as privacy, trust, security, and usability.

Another extension of this research is the further application of these design guidelines and further validation experiments. It would be an interesting long-term study to observe the effect of the design guidelines in a real-life system on the market, to observe their relevance over a longer span of time, and to track and investigate the impact of their development.

Another promising direction for future research is the development of an Inspection Method (Nielsen & Mack, 1994) for the evaluation of EPSs. For instance, heuristic evaluations or checklists for diagnosing interaction design defects in online EPSs could be derived from the set of guidelines presented, thus paving the way for improvements and changes in the current and future systems.

NOTES

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