User-friendly Locations of Error Messages in Web Forms: The right place is on the right side of the erroneous input field

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March 2011

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Abstract

There are several ways to place an error message in a web form. A preliminary study of web conventions showed that the most common approach is to display error messages embedded in the form. The six possible locations for this approach, (1) right, (2) left, (3) above and (4) below the erroneous input field, as well as (5) on the top and (6) at the bottom of the form were used in an online study with n = 303 participants. Results of efficiency, effectiveness and satisfaction demonstrate that the locations near the erroneous input field lead to a significantly better performance than the error messages on the top and the bottom of the form; in addition error messages on the right side of the erroneous input field were subjectively evaluated as the most satisfying and intuitive by participants. These results show possibilities for improvement in online shops, where error messages often are displayed on the top of a form.

Introduction

Many companies ask people to submit information via the web. For a successful interaction with the customer web forms are therefore a crucial component of online shops, contact points, social applications and so on. According to Jarrett and Gaffney's definition, a web form is a web page that has boxes a user can type into (Jarrett & Gaffney, 2008). There exist several types of web forms: Registration forms are often used as gatekeepers to social communities, checkout forms stand between people and companies products and data input forms are used to share or search information (Wroblewski, 2008). Although web forms are very common, people usually don't like to fill them out (Wroblewski, 2008). They are seen as obstacle between what people want and how people can get it (e.g. buy a book, apply for a job).

One of the most important factors of a web form are error messages (Wroblewski, 2008). They show when users cannot continue completing a form and how to solve the situation. The main goal is to get them back to their task as quickly as possible (Jarrett & Gaffney, 2008; Wilska, 2004). Nevertheless, error messages are one of the most frustrating experience when using computers (Ceaparu, 2003; Lazar & Huang, 2003). Although there are several guidelines how to design a good web form (e.g. Bargas-Avila et al., 2010), error messages cannot be avoided completely. Jarrett (2008) differentiates between miscellaneous error messages in web forms, e.g. typing errors, transcription errors and send errors. Error messages can vary on a broad diversity of features, including the format and the type (text style, size and color), use of graphical features, the location in the form, the wording and the time when an error message appears.

Theoretical Background

General Guidelines and Empirical Research about Error Messages

There are many guidelines that try to address questions regarding the usability of error messages, concerning often the verbalization and the design of error messages. Nielsen (2001) and Linderman and Fried (2004) stressed that an error message must be precise, constructive and polite. Furthermore Nielsen (2001) also recommended to never delete users' input after an error occurred and to help users to reduce work by guessing the correct action. Lazar and Huang (2003) and Wilska (2004) emphasized that an error message should never blame users. Wilska (2004) suggested therefore that a fault-free declarative language should be used, stating the problem that needs to be fixed or the requirements for completing a task.

Padilla (2005) underlined that the visual design attributes of an error message should attract users' attention and therefore be clearly distinguished from the rest of the user interface. Crawford (2005), Becker and Mottay (2001) and Padilla (2005) recommended the color red and a bold font for the design of an error message. Becker and Mottay (2001) indicated that the color red has not the same meaning in Asian countries though. Facing the question, if an error message should appear immediately or after the form submission, the International Organization for Standardization recommended to show the error message immediately after leaving a field (ISO/IEC-9241, 1996-2002). These guidelines can help to design more useful error messages, but they are often vaguely formulated and there exist only a few empirical studies, as already Bargas-Avila, Oberholzer, Schmutz, De Vito and Opwis (2007) observed. Correspondingly, there are only a few empirical studies how to guide the user in a web form when an error happens.

Brown (1983) was one of the first who recognized the importance of error messages. He implemented an experiment with 15 different compilers and recognized that little forethought is given to the production of error messages, as well as the potential recovery

after an error has been made. He suggested that there should be a deliberate and sustained effort to focus attention on the quality of error messages.

Wenger (1991) studied the issue of determination and maintenance of social identity in Human-Computer Interaction. Twenty subjects used either a direct manipulation or a command interface that presented an unforeseeable error message that was either consistent or inconsistent with the interface's previous pattern of interaction. Results indicated that direct manipulation interfaces were more likely to lead to the creation of social expectations and that users of the direct manipulation interface who experienced an inconsistent error message expressed intense negative affective responses.

Lazar and Huang (2003) analyzed browser error messages and discovered that they often don't meet the most basic guidelines for a successful user experience. The authors conducted a laboratory experiment with 34 participants who evaluated seven real browser error messages and the same seven messages with an improved text that was more user-friendly and less technical. The result showed that users evaluated the improved error messages as more positive; they understood better what occurred and they were more confident in responding to the error.

A study by Tzeng (2004) with 269 participants analyzed how to make users feel better when they face error messages. The results showed that while the computers' actual performances still dominated the users' assessments of the program, the computer apologies help to create more desirable psychological experiences for users. Furthermore, emotional icons help to improve the aesthetic quality of the software.

Bargas-Avila et al. (2007) studied when an error message should appear. Two empirical studies with 77 and 90 participants showed that the best way of presenting error messages is to provide the erroneous fields after users have completed the entire form. Hence, the authors disagreed with the ISO guideline (ISO/IEC-9241, 1996-2002) that

recommended immediate feedback. They postulated a "completion" or a "revision mode" when users are filling out forms, explaining that during completion mode the users' disposition to correct mistakes is reduced. Although these guidelines and empirical studies are of great importance for creating usable web forms, they don't answer an important question: Where should an error message be displayed within a web form?

Existing Guidelines and Empirical Research about the Location of Error Messages

The location of error messages can make a great impact on the user experience (Biddle, 2007). All the same, at the moment there's no standard way of presenting error messages within forms on the web (Biddle, 2007). There are many ways used to display error messages. This leads to inconsistencies across different sites and causes confusion. The different ways can be grouped into four main approaches:

Approach 1. Embedded error messages at the top or the bottom of the form:

An error message appears at the top of the page before the first form field or label (see Figure 1). Less common, an error message appears at the bottom of the form, after the last form field.

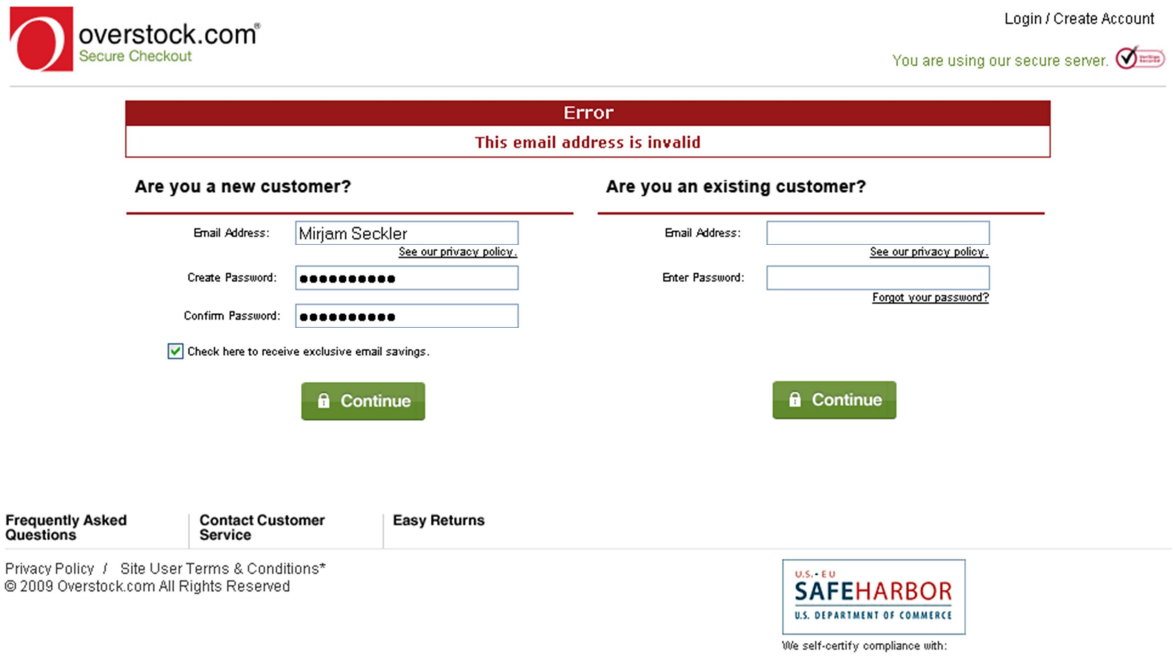

Figure 1. Overstock.com uses an error message at the top of the form (approach 1).

Approach 2. Embedded error messages next to the form field:

There are four different ways how an error message can be displayed within the body of the form (see Figure 2). There's the possibility to locate the error message on the left (Location A) or the right side (Location B) of an erroneous input field, if the label stands on the top. On the other hand, there's the option to display the error message above (Location C) or below (Location D) the erroneous input field. If the label stands above the erroneous input field, the error message is usually located between the label and the erroneous input field.

Approach 3. Pop-ups (alert boxes):

Pop-ups are generally new web browser windows to display an error message (Biddle, 2007; Jarrett, 2008). The pop-up window opens in front of the original form and contains the error message and an OK or close button. Before users can continue filling the web form, they have to click away the pop-up message.

Approach 4. New page:

An error message can be displayed on a new page. Usually there's also a link back to the form.

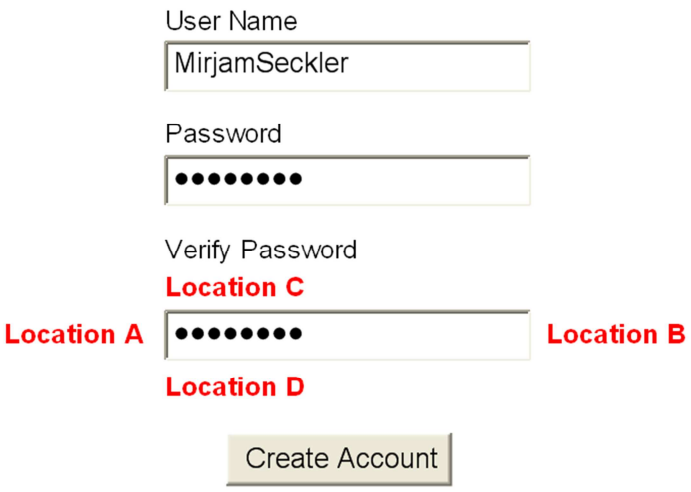

Figure 2. Four possible locations for error messages next to the erroneous input field (approach 2).

There are several guidelines concerning the location of error messages, partly contradictory. According to Padilla (2005) a location at the top of a page is commonly recognized as standard and can help to clearly distinguish the error message from the rest of the application's user interface and capture the user's attention. Nielsen (2001), however, claimed that users look at the page's actionable part first (i.e. the area with the form fields). Thus, a location at the top of a page is not recommended because users don't notice the error message at this location. Crawford et al. (2005) emphasized that error messages should always be placed on the screen in a location where they are likely to be seen and appropriately attributed to the correct question. Featherstone (2005) suggested that placing the error message to the right of the field supports easy scanning. Wroblewski (2008) recommended a combination of an error message at the top of the form as prominent placement and a second message next to an erroneous input field to additionally highlight this field. Biddle (2007) dissuaded from using pop-up windows informing the user which fields need correction. Users tend to close the pop-up windows before they have had time to register what the message was saying (a phenomenon that is reported also by Bargas-Avila et al., 2007). Furthermore, pop-up windows are often used for advertisement.

Other authors accentuate that different kind of error messages should have different locations. According to Wilska (2004) pop-up windows are well-suited for error messages that inform users of problems they can't fix or that require only basic action. If the problem at hand requires them to do something more substantial, for instance to retype information, Wilska (2004) recommended to use an on-screen error message directly above or next to the field. Jarrett (2008) distinguished between even more different types of error messages. On the one hand, pop-up windows or top of the page messages are well-suited for send errors and privacy errors because there's more space for explanations.

On the other hand, an error message next to the field is preferable for typing and transcription errors (and for a small number of category errors).

The only empirical study about the location of error messages (to the author's knowledge) is from Mochovak (2005). Mochovak used an existing survey web form and compared error messages at the top of a page or directly under an erroneous input field. The results from 42 participants showed that they missed the initial appearance of error messages up to 40% but different approaches for presenting the error messages did not result in statistically significant differences. There was also no significant difference in the efficiency (total time spent dealing with the error message). The subjective rating of usability correlated with time to complete an error but not with the number of times the error message was noticed. Participants preferred having error messages displayed under the erroneous input field. The author gave two possible explanations why users missed error messages often. First, users have to get familiar with the interface and the general task. That's why at the beginning users often missed error messages; the performance increase with messages that appeared later in the form. Second, the high miss rate can be the result of the change blindness effect. Change blindness is defined as the failure to detect what should be an obvious visual change in a visual field (Simons & Rensink, 2005) and this effect might also occur when using error messages (Hudson, 2001).

This study gives a small insight about where to place error messages but there are four important shortcomings. First, there are more than these two possible locations of error messages. We don't know how these two possibilities perform in comparison with other locations. Second, Mochovak's (2005) results deal mainly with soft error messages that allow users to continue with their task without any correction (i.e. the message is only a warning). Is there a difference to hard error messages that can't be ignored? Thirdly, the

type of survey question and complexity of the error instruction were confounded in this study. Fourthly, the statistics in this study are sometimes imprecise and incomplete.

Although there are several guidelines and an empirical study that give recommendations where to place an error message in a web form, it's still not clear which location is the most usable in terms of efficiency, effectiveness and satisfaction (Usability definition from ISO/IEC 9241-11, 1998). The goal of this study is to examine different location regarding these factors. In order to clarify the practical relevance and to allow an accurate formulation of hypotheses, the possible locations of error messages were first evaluated in a preliminary study about web conventions; this is reported in the next section.

Preliminary Study

To determine which are the most common locations of error messages, we decided to analyze the 100 most popular online shops (using the Alexa Traffic Rank, 2010) and 100 online shops at random (using StumbleUpon, 2010).

World's 100 top shopping web sites

The Alexa traffic rank website lists the most popular websites of the world. Popularity means a combination of average daily visitors and page views over the past month. There's a category *shopping* where the 100 most popular shopping websites are listed (e.g. Amazon, Ikea and Overstock). We used this list to determine the error message location in each online shop. Because some shops have different top-level domains (TLDs), they are listed twice and more. In this case, only one top-level domain was used for this study.

100 shopping websites at random

To avoid using only popular websites, we added another 100 websites at random. Therefore, we used StumbleUpon to randomly select 100 shopping websites. StumbleUpon is a discovery engine that finds and recommends web content to its users. There is a category *shopping* with an unknown number of sites. For the analysis, only sites from this category were used. The author stumbled through the websites by clicking the *stumble*-button until 100 websites were registered.

Procedure

For each of the 200 shopping site, the author analyzed the placement of the error messages with the following procedure: (1) Access the website, (2) buy a product, (3) click the checkout button and (4) submit the check-out form with wrong and missing information and check at which location the error messages appear. Then the ordering process was aborted. If there was a login form before the possibility to shop, then this login form was used for producing the error messages.

Results

The web conventions show that there are still several approaches where to place an error message nowadays. Four single approaches and a combination of the two embedded approaches (see Table 1) can be identified. Seventeen respectively 18 websites had to be excluded from the analyses due to multiple top-level domains, because there wasn't a web shop (coupon collections or communities), because the sites were only an overview of several different shops (forwarding site) or because they weren't accessible (temporarily unavailable).

Embedded messages are the most common of these approaches (see Table 1). In total, the error messages embedded in the form cover 64.9% of all cases. The study from Bargas-Avila et al. (2007) showed that embedded error messages have a good performance

furthermore. Therefore, this study compares the six different locations embedded in the form. Due to feasibility reasons it was decided not to test combinations of different locations for the time being. Although pop-up messages are frequently found (21.8%), we will not test this approach. The study from Bargas-Avila et al. (2007) already indicated that pop-ups are disadvantageous in many ways. If there's more than one error in a form, then a pop-up has an adverse effect because users cannot remember all mistakes and forget a large part of the message. For the same reason it was also decided not to test the new page approach.

Table 1

Different Approaches for the Location of Error Messages in Online Shops (June, 2010)

Approach	Top sites	Random sites	Total
Embedded, outside the body			
Top of the form	40	35	75 (45.5%)
Bottom of the form	1	3	4 (2.4%)
Embedded, next to the erroneous input field			
Left of the erroneous input field	1	0	1 (0.6%)
Right of the erroneous input field	5	6	11 (6.7%)
Above erroneous input field	4	0	4 (2.4%)
Below erroneous input field	5	7	12 (7.3%)
Embedded, combined	17	2	19 (11.5%)
Pop-up (alert box)	10	26	36 (21.8%)
New page	0	3	3 (1.8%)
Total	83	82	165 (100%)

Summary of the Main Study and Hypotheses

The present study aims to investigate how the six different embedded error message locations (see Figure 3) differ regarding efficiency, effectiveness, satisfaction and preference ratings. Therefore an online study with an online shop, an ordering process and a final questionnaire was developed. During the ordering process four inevitable error messages were shown analogous to the study by Mochovak (2005) and Bargas-Avila et al. (2007). We used the following hypotheses:

Efficiency-hypotheses. Supposing that error messages near the erroneous input field (left, right, above and below) quickly direct users attention to the problem zone (Wilska, 2004) and therefore shorten the search process, these four locations will lead to significantly shorter time to first click than the other two locations (at the top and the bottom of the form). The fastest interaction should be reached with error messages above and below the erroneous input field, because these locations shorten the scan path and therefore allow a rapid processing (see e.g. Penzo, 2006). No significant differences are expected for completion times of the whole form, because the error message location is expected to be a small factor in the entire interaction process to make a significance difference (analogous to Bargas-Avila et al., 2007).

Effectiveness-hypotheses. According to Nielsen (2001), users look at the pages' actionable part first, thus an error message at the top and the bottom of the form are not likely to get noticed. Therefore it is expected that users will make with this placement the same error more than once which is defined as consecutive error (Bargas-Avila et al., 2007). Error messages on the left and on the right of the erroneous input field should be noted more likely because they stand out and therefore the consecutive error rate should be lowered.

Satisfaction-hypotheses. No differences between the six locations are expected for the evaluation of the online shop, again because the error message location is expected not to have sufficient influence to alter the overall evaluation.

Preference-hypotheses. Error messages at the top and the bottom of the form are expected to have the lowest preference ratings, because they are also expected to be inefficient and ineffective.

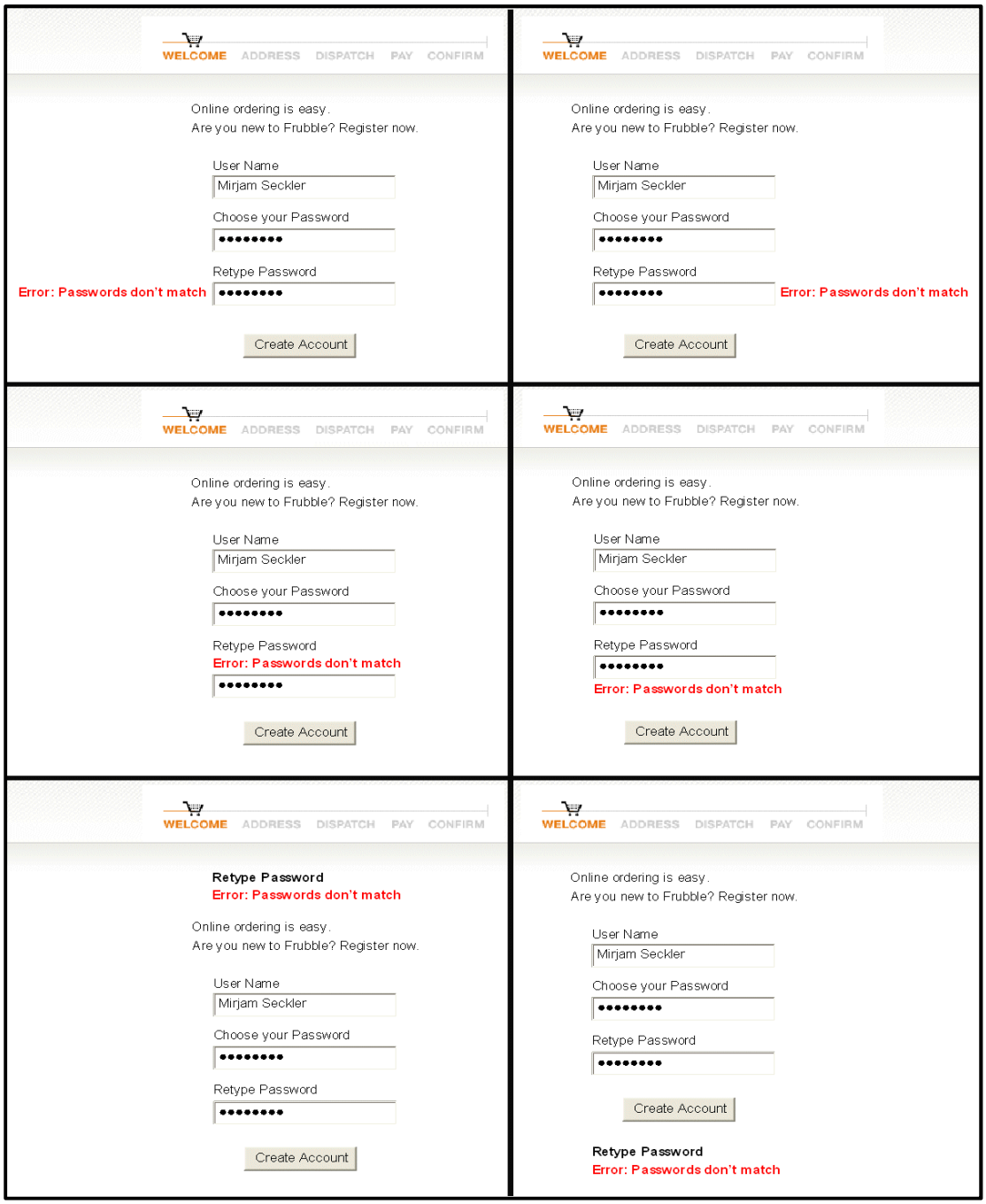

Figure 3. Example of the six different error message locations (translated by the author).

Method

Experimental Design

In order to study the effects of different locations of error messages on user performance and subjective satisfaction, an unrelated samples design was used. The independent variable was the location of the error messages with six levels (right, left, above, below, top, and bottom). The primary dependent variables were user performance (efficiency and effectiveness of corrections), subjective satisfaction with the online shop and subjective preferences of the error message location.

Measurements

Efficiency was measured by the time needed to correct an error message (from page load until submit) and the time from load to the first click (using Javascript events) in the field of the error message. Effectiveness was operationalized by the number of consecutive errors. Finally, subjective satisfaction with the online shop was measured with three validated questionnaires: the WOOS (Yom & Wilhelm, 2004), the NASA-TLX (Hart & Staveland, 1988) and the SAM (Lang, 1980). The WOOS questionnaire measures perceived orientation in online shops (Yom & Wilhelm, 2004). It contains seven questions about the structure, efficient locating, meaningful naming and orientation in the online shop. Participants rated these seven questions on a 5-point Likert scale. The NASA-TLX is a subjective workload assessment questionnaire consisting of six items asking for the amount of experienced mental, physical and temporal demands, as well as ratings of performance, effort and frustration experienced during task completion (Hart & Staveland, 1988). The questionnaire was implemented without the weighting function to reduce time. Newer research showed that there's no substantial loss in this shorter version of the NASA-TLX (Hart, 2006). Participants rated the six items on visual analog scales which were recalculated in 100-point scales. The self-assessment manikin (SAM) is a non-verbal pictorial rating scale with the three dimensions pleasure, arousal and

dominance (Lang, 1980). Subjective preference was measured by presenting all locations with screenshots and asking for the most and least preferred one. For the purpose of a manipulation check, participants were also asked to rate the perceived authenticity of the online shop and to state if they encountered error messages.

Materials

Online shop: For an authentic online shop experience, a shop for clothing with navigation, product listing pages and shopping basket was programmed (similar to Tuch, Roth, Hornbæk, Opwis & Bargas-Avila, 2011). In total, the shop contained more than 1300 different product items. The screenshot for the start page can be seen in Figure 4.

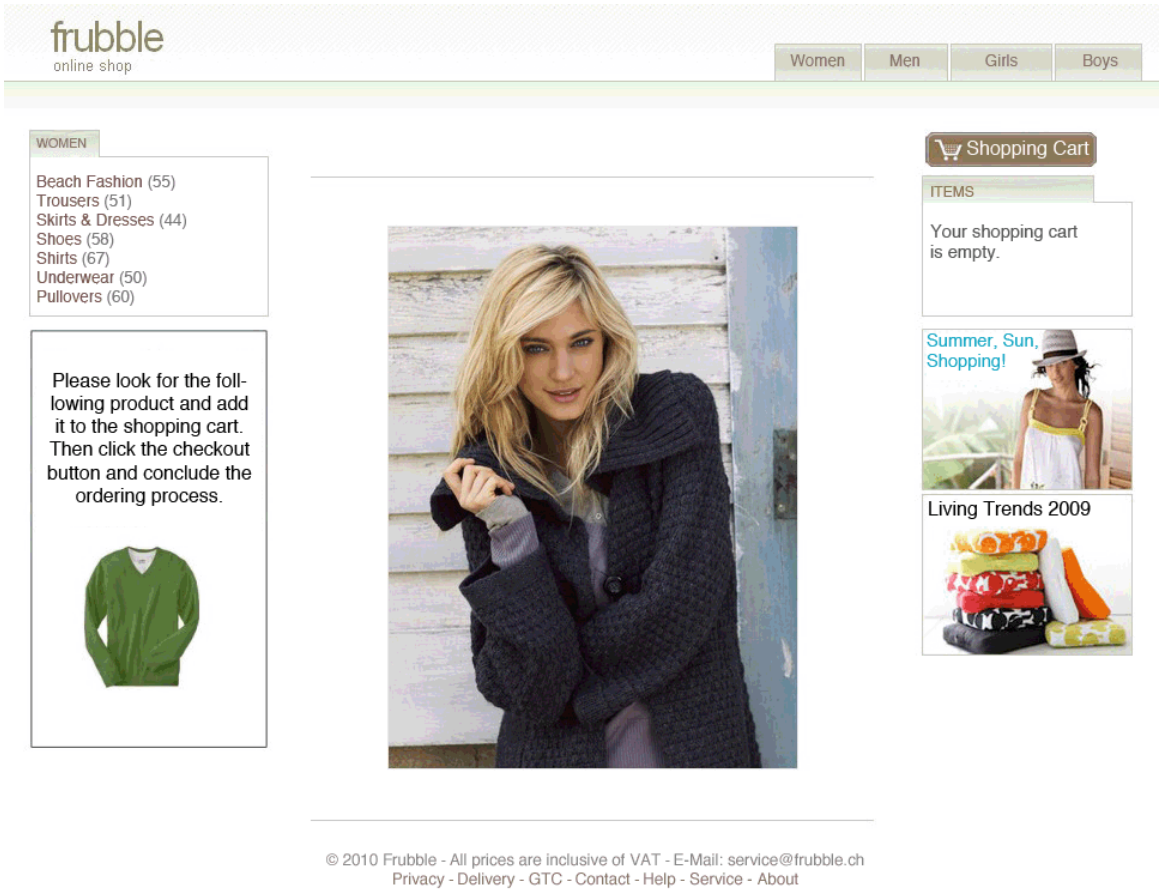

Figure 4. Start page of the online shop including the task description (translated by the author).

Ordering process: The ordering process consisted of five different web forms (welcome, address, dispatch, payment, confirm). The sequence of the forms was taken from Amazon (amazon.com) and shortened (*items* and *wrap* were left out). The form fields were taken from different online shops. The global design followed important usability guidelines, e.g. the labels are placed above the input fields (Penzo, 2006) and there was minimal distraction to keep participants focused on completing the forms (Wroblewski, 2008). There was a progress indicator for giving people a sense of the scope of the ordering process (Wroblewski, 2008).

The key factor of the experiment were four built-in, unavoidable error messages (see Bargas-Avila et al., 2007; Mochovak, 2005) that appeared all separately on different forms (see Table 2). Different error message types were used to simulate different problems and to provide a realistic scenario (see Table 2 for different types and exact error messages). Two of the four error messages (birthday & payment method) demanded an exact reading of the text and were therefore suited to measure effectiveness, because not reading these messages leads to consecutive errors. The other two messages only ask for a new input.

The error messages were written in red color. The distance between an error message and the erroneous input field was 20 pixels for the left and right location; a line break above the erroneous input field respectively below the label for the above variant and a line break below the erroneous input field for the below variant. The error messages at the top of the form were double-spaced and stood a line break above the form title. The first line was black and contained the erroneous label; the second line was red and contained the error message. The error messages at the bottom of the form used the same design; the location was a line break below the next-button (see Figure 3). The correct locations were implemented for the following browsers: Internet Explorer 7, Internet Explorer 8, Firefox 3.5, Firefox 3.6 and Safari 4, therefore only users using these browsers were allowed to participate.

Table 2

Error messages in the ordering process (translated by the author)

Field (Form)	Error Messages	Description	Visual stimuli	Type
Password again (Welcome)	Error: Passwords don't match	The system claimed that "Password" and "Password" again didn't match	Input fields: Password" and "Password again" were empty	Typing error
Birthday (Address)	please use following format: 24/05/2010	Day-month-year had to be separated by ''/'' and day/month had to have two digits, the year four digits (e.g. 21/02/1979)	Input field: "Birthday" was empty	System restriction error
Payment method (Pay)	is currently not available	The system claimed that the elected payment method was currently unavailable	Drop down menu: There was no change	Category error
Confirmation code (Confirm)	Error: Confirmation code is not correct	The system claimed that the confirmation code was not correct	Input field: "confirmation code" was empty, new Captcha was generated	Transcription error

Questionnaire: The questionnaire for the subjective satisfaction and preferences was implemented using Unipark.de (EFS Survey 7.0).

Procedure

The online experiment took place from October 2010 to November 2010 and was conducted in German. Starting from an introduction page, participants were randomly assigned to one of the six experimental conditions (see Figure 5) and directed to the online shop. The task in the shop was written on a banner and involved locating one product. The shopping task served only as real shopping experience, though. After putting the product in the shopping cart, participants could click on a checkout-button. This led them to the checkout process with the five different forms and the four error messages (see Table 2). The error messages appeared

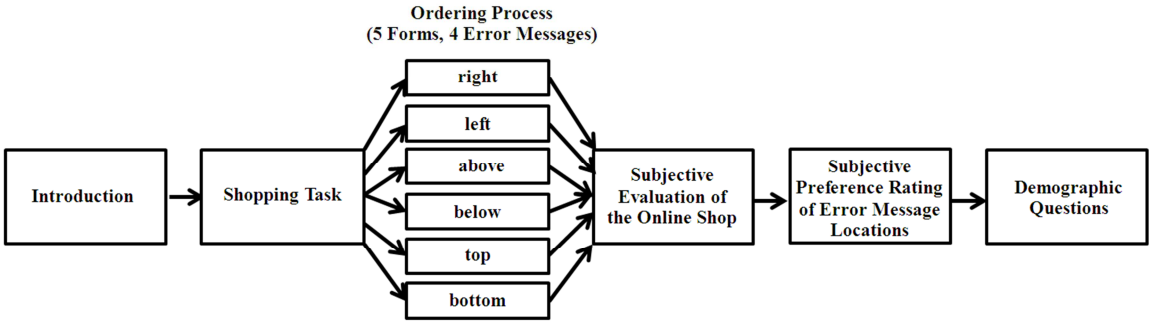

Figure 5. Overview of the experimental procedure.

after the forms were submitted and it was not possible to skip the error messages without correction. After having finished the process, users were directed to the final questionnaire.

First, three ad-hoc items about usability ("Please rate how usable the online shop is"), frustration ("Please rate how frustrated you have while interacting with the online shop") and the handling of the online shop ("Please rate how easy resp. difficult the online shop was to handle") were asked (7-point Likert scale), followed by the WOOS questionnaire the NASA-TLX and the SAM questionnaire. Then, the participants had to rate the authenticity of the online shop and were asked if they noticed error messages. Furthermore they were asked for the most favored and the most annoying location of error messages. At the end, there were some demographic questions.

Participants

The participants were recruited from a database of the Department of Psychology, University of Basel, containing the data of people interested in attending studies. An iPhone 4 was raffled between all participants as an incentive. The participants were contacted via email containing the participation link. In total 482 people started the experiment, of which 124 aborted the study after the introduction page. Nineteen participants quit after the first error message appeared, 24 later during the ordering process. Six participants dropped out during the final questionnaire and six participants used a mobile device and were therefore

excluded. Another five participants indicated visual color impairment and were also excluded. In total this leads to a drop–out rate of 37.14%.

A total of n = 303 participants were included in the analysis (34% male, 65% female, 1% did not indicate their gender). The mean age was 28 years (*SD* = 9.99; range: 15 – 64). The average self-rated computer knowledge on a scale from 1 to 7 (1 = no experience; 7 = expert) was 5.49 (*SD* = 0.92). Ninety-eight percent of all participants were familiar with the Internet using it several times a week (7%) or daily (91%). The average self-rated online shopping knowledge on a scale from 1 to 7 (1 = no experience; 7 = expert) was 4.68 (*SD* = 1.35). Eighty percent of all participants already bought goods in online shops more than five times, 67% even more than 10 times.

Results

For all statistical tests an alpha level of .05 was used. Furthermore, all data were checked if they meet the required conditions for the statistical tests. All time values had to be log-transformed to achieve normal distribution. Differing sample sizes within the statistical values are due to individual missing data values. Before the main analysis, a manipulation check and an analysis of covariates was conducted.

Manipulation check

First, the online shop was checked for authenticity. An analysis of variance (ANOVA) for independent samples with the factors error message location and authenticity of the online shop showed no significant differences ($F(5, 297) = 2.18$, $p = .056$, $\eta_p^2 = .04$), therefore the manipulation was successful. The average rated authenticity on a scale from 1 to 7 (1 = not realistic; 7 = very realistic) was 5.12 (*SD* = 1.61). Second, a chi-square test with the factors error message location as independent variable and participants' indication if they noticed error messages as dependent

variable was conducted. The analysis showed that the experimental factor error message location did not lead to different ratings and was therefore successfully manipulated, $\chi^2(10, N = 302) = 11.33, p = .332$.

Covariates

The analysis of demographic factors with one-way ANOVAs showed no significant differences between the experimental groups' age distribution, computer knowledge, Internet usage and online shopping knowledge. A chi-square test indicated that there are also no significant differences in gender distribution over the six conditions, as well as in the browsers used.

Efficiency

First, an ANOVA for independent samples with the factors error message location as independent variable and total time per form with error messages as dependent variable was conducted. All values are shown in Table 3. As expected, there were no significant differences for the forms with the "birthday" ($F(5, 295) = .21, p = .959, \eta_p^2 = .00$) and the "confirmation code" ($F(5, 288) = 1.58, p = .166, \eta_p^2 = .03$) error message. Unexpected significant results were found for the "password" ($F(5, 297) = 2.42, p = .036, \eta_p^2 = .04$) and "payment method" ($F(5, 295) = 4.95, p < .001, \eta_p^2 = .08$) error message. Descriptive data show that for both error messages the location at the bottom led to lower efficiency than the other locations. Post-hoc tests with Scheffé revealed no further significant differences for the password error message; significance differences were found for the payment method error message, indicating that the location at the bottom ($M = 11.02$, 95% CI [9.52, 12.52]) led to a significantly lower efficiency than the error messages above ($M = 6.50$, 95% CI [5.00, 7.99], $p = .004$), below ($M = 6.90$, 95% CI [5.39, 8.41], $p = .014$) and on the right side ($M = 7.41$, 95% CI [5.91, 8.91], $p = .049$) of the erroneous input field.

Table 3

Average Time from Load to Submit in sec for each Location

	right		left		above		below		top		bottom	
Error Message	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)
Password	51	18.29 (17.41)	47	18.18 (12.57)	51	15.86 (8.33)	50	14.11 (6.15)	52	17.07 (12.97)	52	22.83 (21.63)
Birthday	51	15.28 (8.63)	47	15.67 (10.61)	51	14.53 (6.62)	49	16.16 (11.48)	52	16.41 (10.26)	51	16.73 (11.44)
Payment method	51	7.41 (4.36)	46	7.87 (6.40)	51	6.50 (3.02)	50	6.90 (4.04)	52	7.65 (3.06)	51	11.02 (9.13)
Confirma-tion code	50	10.93 (4.92)	45	10.51 (4.75)	51	12.16 (10.30)	50	11.94 (6.25)	52	10.49 (4.72)	51	11.97 (5.72)

Note. The displayed values are not log-transformed; statistical tests are based on the log-transformed data.

Second, the time from loading to the first click in the field that needed to be corrected was analyzed. Analysis using ANOVA revealed that there were significant time differences for all error messages, password with $F(5, 220) = 7.34, p < .001, \eta_p^2 = .14$, birthday with $F(5, 258) = 9.47, p < .001, \eta_p^2 = .16$, payment method with $F(5, 262) = 10.68, p < .001, \eta_p^2 = .17$ and confirmation code with $F(1, 286) = 2.78, p = .018, \eta_p^2 = .05$. For the descriptive data see Table 4. To compare the different locations, contrasts were calculated according to the hypotheses. A contrast analysis was conducted to test if placing the error messages directly near the erroneous input field resulted in a shorter timespan to the first click than the other two locations (bottom and top). As expected, the error messages at the top and the bottom performed worse than the other locations, password with $F(1, 221) = 15.98, p < .001$, birthday with $F(1, 263) = 39.09, p < .001$, payment method with $F(1, 263) = 41.38, p < .001$ and confirmation code with $F(1, 286) = 10.14, p = .002$. There was no significant difference between the four locations near the erroneous input field.

Table 4

Average Time from Load to First Click in sec for each Location

	right		left		above		below		top		bottom	
Error Message	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)
Password	41	3.86 (2.56)	37	4.27 (3.42)	40	3.70 (2.88)	36	3.82 (1.65)	38	4.12 (2.28)	34	6.51 (2.97)
Birthday	42	3.24 (2.27)	43	3.04 (1.79)	46	3.33 (3.05)	45	3.57 (2.12)	46	4.96 (3.07)	47	4.97 (4.29)
Payment method	47	2.89 (1.62)	43	3.05 (2.50)	46	3.01 (1.72)	46	2.77 (1.10)	41	3.87 (1.83)	46	5.33 (4.64)
Confirma-tion code	47	2.90 (1.52)	43	2.40 (1.10)	51	2.91 (1.87)	46	3.00 (1.93)	52	3.41 (2.21)	52	3.56 (2.19)

Note. The displayed values are not log-transformed; statistical tests are based on the log-transformed data.

Effectiveness

According to the study design, only the error messages for the birthday and for the payment method are relevant for the effectiveness, because only these error messages demanded an exact reading of the text. A chi-square test was calculated with all four error messages to confirm this assumption. As expected, there were no significant differences in consecutive error rates between the error message locations for the password ($\chi^2(5, N = 287) = 2.08$, $p = .838$) and confirmation code ($\chi^2(5, N = 303) = 3.54$, $p = .617$) error message. Therefore, these two error messages were left out in this section.

The location of error messages had a significant impact for the correction of an erroneous input field (see Table 5). The results of chi-square tests indicated that there are significant differences between the locations, $\chi^2(5, N = 271) = 11.74$, $p = .039$ (for the birthday error message) and $\chi^2(5, N = 303) = 12.60$, $p = .027$ (for the payment method error message). For further analyses configural frequency analyses with Eye (Grüner, 2008) were conducted. A significant difference between expected and effective frequency was found for the location at the bottom for the birthday error message ($z = 2.26$, $p = .012$) and for the location at the top for

Table 5

Successful Error Correction and Consecutive Error Rate as a Percentage of each Location

Error Message		right	left	above	below	top	bottom
Birthday							
	valid	90.7	86.7	91.3	80.0	81.8	68.8
	invalid	9.3	13.3	8.7	20.0	18.2	31.3*
Payment method							
	valid	94.1	95.7	90.2	94.0	78.8	82.7
	invalid	5.9	4.3	9.8	6.0	21.2*	17.3

Note. *p < .05

the payment method error message ($z = 2.05$, $p = .020$), indicating that the consecutive error rate for these two locations were significantly higher than for the locations near the erroneous input field.

Subjective Satisfaction

To test whether the locations differ regarding subjective satisfaction with the online shop, one-way ANOVAs for independent samples were performed. Results indicate that there are no significant differences for the single items usability ($F(5, 297) = .94$, $p = .457$, $\eta_p^2 = .02$), frustration ($F(5, 297) = 1.07$, $p = .377$, $\eta_p^2 = .02$) and handling ($F(5, 297) = 1.51$, $p = .186$, $\eta_p^2 = .03$). Likewise, no significant differences were found for the WOOS questionnaire ($F(5, 297) = 1.03$, $p = .400$, $\eta_p^2 = .02$) and for the SAM (valence: $F(5, 265) = .91$, $p = .477$, $\eta_p^2 = .02$; arousal: $F(5, 264) = .50$, $p = .777$, $\eta_p^2 = .01$; dominance: $F(5, 264) = .33$, $p = .896$, $\eta_p^2 = .01$). However, a difference was found for the NASA-TLX ($F(5, 278) = 2.49$, $p = .032$, $\eta_p^2 = .04$). Descriptive data show that the location at the bottom and above the erroneous input field led to a higher cognitive load (see Figure 6). Post-hoc test with Scheffé revealed no further significant differences.

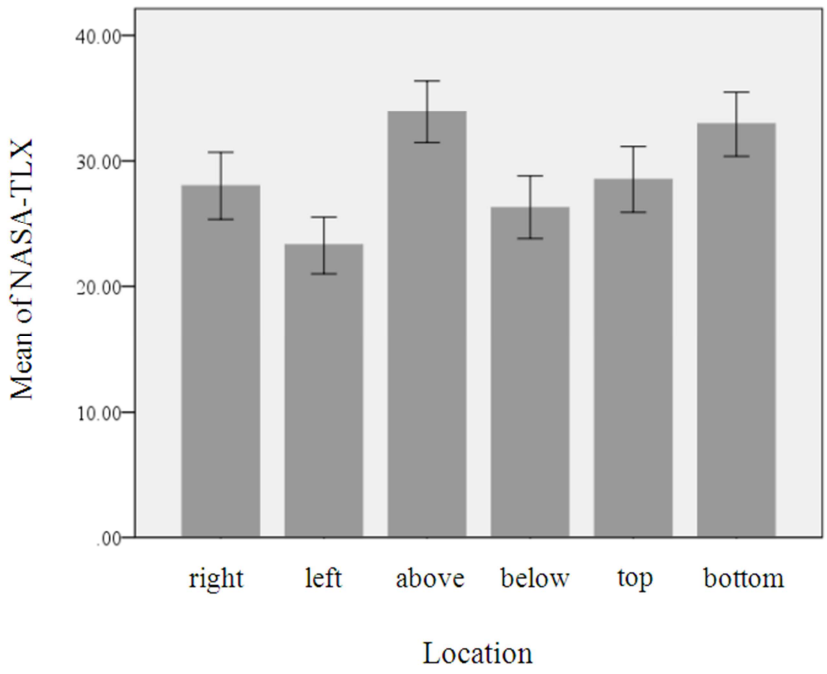

Figure 6. Mean and standard errors of the Nasa-TLX for each condition.

Subjective Preference

Subjective preference data were analyzed with a chi-square goodness of fit test. There were significant differences in the preferred location, $\chi^2(5, N = 303) = 242.84$, $p < .001$, as well as regarding the most annoying location $\chi^2(5, N = 303) = 130.05$, $p < .001$. Furthermore, there was a significant difference regarding where participants expect error messages, $\chi^2(5, N = 303) = 103.00$, $p < .001$. All values are shown in Table 6. The least preferred and at the same time the most annoying location was the one at the top, followed by the location at the bottom and on the left. The preferred error message location is on the right side of the erroneous input field, this was also the location where participants indicated to expect the error messages.

Table 6

Answers for subjective preference ratings (numbers represent participant count)

Error Message	right	left	above	below	top	bottom
Preferred Location	139	27	48	71	7	11
Most annoying location	17	83	33	11	100	59
Expected Location	104	29	51	70	33	16

Discussion

The preliminary study showed that there are currently many locations where error messages are displayed in a web form. There are four locations directly near the erroneous input field (right, left, above and below the field) and two locations outside the form body (on the top and at the bottom of the form) that were chosen for experimental evaluation. The main experiment indicates that all in all error messages on the right showed the best results, followed by error messages below an erroneous input field.

Regarding the efficiency of the different locations, the error message near the erroneous input field performed significantly better than the other two locations which were further away from the erroneous input field. This result is consistent with the experimental hypothesis and the guideline from Featherstone (2005) but contradict the findings from Mochovak (2005), who didn't find a difference between the error message at the top and below the erroneous input field. In this study, the bottom location had even an influence on the overall time used to correct the forms. A closer look shows that this was the case when the erroneous input field was at the top or almost on the top (birthday and payment method), leading to a longer distance between field and error message.

The analyses of effectiveness countenance these results. The error messages on the top and at the bottom cause higher consecutive error rates. This finding supports Nielsen's (2001) opinion that users look at the page's actionable part first and contradicts Padilla (2005) who claims that error messages on the top of the page capture the user's attention. The results are also comparable with the consecutive error rate in the study from Mochovak (2005), suggesting that not only soft error but also hard error messages can cause high consecutive error rates. Already Hudson (2001) pointed out that error messages are likely to get overlooked and referred to the change blindness effect, which occurs because in form validation, the original page is sometimes redisplayed with only little changes. The results of the actual study support Hudson's observation as well as Simons and Rensink's (2005) statement that objects in a scene that preferentially receive attention, are more likely to be encoded and compared. It's likely that the error messages near the erroneous input field get more attention and therefore the change blindness effect as well as the consecutive error rate is lower.

As expected, no significant differences were found for the subjective evaluation of the online shop (WOOS, SAM, ad-hoc items). A possible explanation is that the interaction time with the online shop was too long for an unpopular error message location to have an impact on the entire evaluation. Furthermore, the location of an error message may be a factor that is too small to be able to influence the evaluation of an online shop. Unexpectedly, the NASA-TLX showed a significant difference between the locations, indicating that the error messages at the bottom and above the erroneous input field caused the highest cognitive load. The former already showed disadvantages in the efficiency and effectiveness and may therefore also cause high cognitive load. The error message above the erroneous input field may lead to a high cognitive load because this location is also used for the field label and can therefore elicit confusion. These findings underline

additionally the clear advantage of the locations on the right, the left and below an erroneous input field.

The subjective preference ratings shed more light on the question which location of the three remaining is the best. Subjects clearly preferred error messages on the right side. A possible reason may be that this is also the location where subjects expected the error messages. An explanation can be that because our reading system goes from left to right, the reaction to an input should be on the right side as well. The second most preferred location is the location below an erroneous input field. This result supports the findings from Mochovak (2005). The disadvantage of this location is the increased vertical space that is needed for displaying an error message. This can be a problem for longer forms, particularly.

Although in this study different types of error messages were used (typing error, system restriction error, category error and transcription error), there was no significant difference regarding usability measures. This contradicts Jarrett's (2008) suggestion that different types of error messages fit to different locations. Although there is more space on the top of a form for an error message, in the actual study this location led to lower efficiency and effectiveness in contrast to the locations near the erroneous input field. Moreover, the suggestion that different locations should be used for different types of error messages result in an inconsistent solution and may cause problems to users.

The results obtained in this study are quite interesting if compared with the preliminary study about where error messages are currently placed. In most online shops, the error messages appear at the top of the form. This may be the case because this location is more easily to program than error messages near an erroneous input field (the exact location of the erroneous input field can be ignored). Yet, the actual study showed the problems with the location at the top of the form.

Limitations

There are several limitations of this study that have to be addressed. First, this study focused only at the location of a text error message. There are miscellaneous graphical possibilities how to point out an error, for instance to frame or highlight an erroneous input field with additional color or symbols. These graphical possibilities may act as endorsement and may help to improve the interaction. Second, the error messages used in this study were relatively short, maybe longer error messages lead to different consecutive error rates. In addition, this study was conducted online and therefore confounding variables were not controlled. Furthermore, most participants were quite experienced web users. Novice users may have different expectations or show different behavior when handling web forms. Another important factor is that most participants in this study were from Switzerland and therefore the results of the study may not be applied to other cultures. Taking into account that the lettering or the color may have an influence on the perception of error messages there are likely to be different findings in other cultures.

Further work

Further work should explore if the findings from this study can be replicated with longer forms or more than one error message per form. It also may be worth to evaluate a combination of different error message locations. Additionally, eye tracking data would give extended insights where users look at a form and when users notice error messages. Moreover, it would be interesting to investigate different design options (colors, use of graphical symbols) on the perception of error messages.

Conclusion

In this study important insights were achieved, showing that error messages near the erroneous input field lead to the best performance. Among these error messages, the error message on the right side was evaluated as the most satisfying and intuitive. The practical

implications of the current findings are clear. Comparing these results to the findings of the preliminary study, only few online shops display the error message on the right side. In most instances the error messages don't even appear directly near the erroneous input field. In the best case this leads to lower ordering speed and customer satisfaction, in the worst case users are not able to complete the ordering process. Many online shops, small shops as well as the world's leading shops, need therefore improvement in the placement of error messages.

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