Using Autosuggest and Dynamic Querying to Enhance the Usability of Online Banking Interfaces

Master's Thesis of:

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Abstract

Due to the potential cost savings and a very high customer convenience, online banking is still gaining popularity as a delivery channel for banking companies. Altough banks look for innovative services to provide more distinction between them and their competitors, online banking interfaces rarely differ when it comes to enable the search for elapsed transactions. The aim of the present study is to examine to what extent Ajax enabled technologies, such as dynamic querying and autosuggest, can support the users of an online banking interface in searching their elapsed transactions. Dynamic querying was used to set date ranges and amount ranges, whereas autosuggest was used to support the user in searching for transaction texts.

Regarding our data, we advice against the use of dynamic querying to set date ranges in online banking interfaces. In contrast, we found autosuggest to be instrumental in searching for elapsed transactions. However, more investigations need to be conducted in order to make these findings conclusive.

Introduction

Even after the market for broadband Internet connections in European countries became nearly saturated, statistical data of different countries suggest that there is still a considerable increase in online banking customers (APACS, 2007; Shahd & Koch, 2008). This tendency is broadly supported by banking companies that spend large amounts of money on the Internet infrastructure. Bauer, Hammerschmidt and Falk (2005) for instance, stated that the Deutsche Bank invested approximately half a billion US$ per year in their Internet infrastructure. In addition, the acquisition costs in online banking exceeded that of traditional off-line business by 20-40 per cent (Reibstein, 2002; Reichheld & Schefter, 2000). Banks are willing to cover online expenses because they provide numerous benefits. Gopalakrishnan, Wischnevsky and Damanpour (2003) suggest that online banking has the potential to cut the cost of a single transaction from an offline price of $1.07 to an online value of $0.02. Furthermore, they suggest that online banking produces more efficient means of product tailoring as banking companies can suit products to their specific needs faster and easier.

However, one problem is the security of online banking interfaces. Several studies, using the Technology Acceptance Model (Davis, Bagozzi & Warshaw, 1989), highlight the advantages and disadvantages of online banking that persuade customers to switch from paper and pencil to online delivery (Lai & Li, 2005; Pikkarainen, Pikkarainen, Karjaluoto & Pahnila, 2004; Poon, 2008). In the studies that used the Technology Acceptance Model, along with security, usability was found to be a key factor that makes customers willing to adopt an online banking procedure. However, there are few studies investigating the usability of online banking interfaces. Exceptions are the studies of Weir, Anderson and Jack (2006) and Weir, McKay and Jack (2007). In Weir et al. (2007) the effects of metaphors (form-filling metaphor Vs. spreadsheet metaphor) and labeling styles on the usability of banking interfaces were investigated. It was clearly shown that participants in conditions that enabled them to pay bills using old-fashioned forms, which took after paper and pencil forms, performed better than participants in conditions that forced them to use modern spreadsheet forms - although the spreadsheet forms were theoretically timesaving. Weir et al. (2007) did not find a significant effect that was caused by different labeling styles. There was no difference between formal banking terminology and a simpler plain English language. On the other hand, Weir et al. (2006) analyzed the effects of different search functionalities on usability and on the customers will to switch from paper and pencil to online delivery. Their data suggest that providing customers with advanced search functionalities to search for elapsed transactions can encourage them to switch from paper and pencil to online banking.

Considering the findings of Lee and Kim (2002), that banks look for innovative services to provide more distinction between them and their competitors, it is remarkable that today's online banking interfaces rarely differ in assisting the customer's search for elapsed transactions. The process of filtering down all available transaction data to only the data, which are required, is very similar among today's online banking interfaces. In order to enable the search for elapsed transactions, today's online banking interfaces provide the possibility to set a date range, an amount range and sometimes they enable the user to search for a specific kind of transaction (credits/debits) or to search for particular words within the transaction texts. However, today's online banking interfaces all use the same principle of entering data into search fields and afterwards clicking a search button in order to show the transactions, the user wants to see. Potentially supportive techniques, such as dynamic querying or autosuggest (sometimes also referred as dynamic term suggestion or real time query expansion), were not used until now.

Dynamic querying, as described in Ahlberg, Williamson and Shneiderman (1992), uses direct manipulation on sliders to formulate queries, which in turn are used to search in databases. In the study of Ahlberg et al. (1992), dynamic querying with sliders outperformed form-filling methods. In the meantime, dynamic querying was used and analyzed in a huge area of application, which consisted of movie databases (Ahlberg & Shneiderman, 1994), health statistics (Plaisant & Jain, 1994) and photo albums (Kang & Shneiderman, 2000). Graphical visualization of the database and the search results was already used in the initial Ahlberg et al. (1992) study and found to be an important factor for a successful appliance of dynamic querying. Although proven to be generally a great help, not in every case the usage of dynamic querying lead to the desired results (Qing & North, 2003). As Ahlberg et al. (1992) already stated, the usage of dynamic querying sliders can cause problems, especially when data are not evenly distributed.

Therefore, Eick (1994) invented the data visualization slider that could partially solve the problem emerging from the usage of dynamic querying on data that are not evenly distributed. As the name “data visualization slider” suggests, distribution of the data was already shown on the slider itself. Andrienko et al. (2002) investigated the effects of data visualization in the slider area on usability in the field of geographical data visualization. The results of Andrienko et al. (2002) concerning the usage of data visualization sliders with dynamic querying were inconsistent. On one hand, they found these sliders to support search tasks and the detection of spatial patterns. On the other hand, these sliders produced high error rates when they were used by the participants to reveal correlations in the data.

Autosuggest, another supportive technique, immediately adds a drop down menu beneath the search box when a user begins to enter text there. The drop down menu contains of search suggestions, automatically provided by the system. The paper by White and Marchionini (2007), which examines the effectiveness of so called "real-time query expansion", shows support for the usage of autosuggest. Furthermore, they found an improvement of the initial search queries and a higher user satisfaction.

Both dynamic querying and autosuggest require Ajax ("Asynchronous JavaScript Technology and XML") or related techniques running on the website's background in order to be implemented. Ajax, as described in Garret (2005), is a web development technique for building dynamic web applications with richer interactive and graphical capabilities. Ajax combines several well-established standards and enables building web applications that behave in a similar fashion to traditional desktop applications. It breaks with the old-fashioned cycle of entering data, reloading the page and entering data again. However, problems still occur when using Ajax, which cannot be ignored. Paulson (2005) described these problems as follows: first of all, due to its asynchrony that is associated with an increased complexity, Ajax applications are hard to debug. Secondly, there is still no secure development framework available.

Fully aware of these issues, we wanted to conduct a usability study, investigating the effects of dynamic querying and autosuggest in an online banking context, as Ajax (or related techniques enabling similar interaction patterns) supposedly will be secure enough in the near future to be used in this sensitive context. Several attempts to enable such techniques in higher security areas provide evidence for this assumption (Hoffman & Sullivan, 2007; Potter, 2008; Taivalsaari & Mikkonen, 2008).

The aim of the present study is to find out whether Ajax-enabled interaction patterns, such as dynamic querying, data visualization sliders and autosuggest, can successfully be applied to online banking interfaces and support users in finding their elapsed transactions. The results of our study will help the practitioner decide, whether to use these Ajax-enabled interaction patterns in the context of an online banking environment once a secure Ajax-framework has established.

To answer these questions, we compared the usability of standard “Non-Ajax” interfaces, “Simple Ajax” interfaces that used dynamic querying in combination with the autosuggest feature and “Histogram Ajax” interfaces that used data visualization sliders in combination with the autosuggest feature. Beside the factor Ajax, we also manipulated another factor called “chart”, containing of the two stages “with chart” and “without chart”. However, as this paper merely concentrates on the effects of the factor Ajax, no detailed analyses of the factor chart will be presented here. Detailed analyses of this factor can be viewed in the master thesis of Heinz (2009).

In order to measure usability, we collected data of several dependant variables, such as task completion time, task performance, number of mouse clicks, participant’s usability ratings, the perceived workload and the participant’s overall impression of the interface. As the study was conducted using an eye-tracking monitor, gaze data could be gathered and analyzed as well.

While some studies (Ahlberg et al., 1992; Plaisant & Jain, 1994) found an improvement of dynamic querying over the well-known “stop-n-go” forms, different studies (Andrienko et al., 2002; Qing & North, 2003) also found problems emerging from the use of dynamic querying. Due to these conflicting findings in the literature and the fact that dynamic querying and autosuggest had never been used in online banking before, we stated two-tailed hypotheses concerning the differences between the Non-Ajax condition and the two different Ajax conditions. Thus, we expected participants in the Non-Ajax condition to reach other task performance scores and task completion times than the participants in the two Ajax conditions. We also expected participants of the Non-Ajax condition to rate the interfaces differently than participants in both Ajax conditions. Moreover, the Non-Ajax version was supposed to cause other fixation lengths and fixation counts than both of the two Ajax versions.

Ahlberg et al. (1992) and Qing and North (2003) found usability problems emerging from the usage of dynamic querying combined with databases that did not consist of evenly distributed data. Evenly distributed data cannot be guaranteed when it comes to analyzing transactions of private persons. As data visualization sliders address this problem, we expected participants in the Histogram Ajax condition to perform better than those in the Simple Ajax condition and hence, to reach better values in task performance and task completion time. We also expected them to give higher usability ratings and to have a better overall impression of the interface than participants who used the Simple Ajax interface. The Histogram Ajax version was supposed to cause shorter overall fixation lengths and less fixation counts than the Simple Ajax version.

Method

Design

The research reported here used a 2 x 3 factor between-subjects experiment design. The independent variables chosen were chart (with or without chart) and Ajax (Non-Ajax, Simple Ajax or Histogram Ajax). Besides gaze data, two different kinds of dependent variables were collected. According to Hornbaek (2006), objective data and subjective data were recorded. The objective data included the total task completion time and the total number of correct answers participants had written into the guideline. The total number of mouse clicks were also recorded and interpreted as another objective measure. The subjective data consisted of different scales that measured the usability and the participant's satisfaction concerning the tested interfaces. These scales were: The System Usability Scale (Brooke, 1996), measuring the usability and the NASA-TLX (Hart, 1988), measuring the participant's cognitive load. Additionally, data was gathered via a simple non-standardized six-point Likert scale measuring the participant's overall impression of the interface. Moreover, participants were asked if they would like to use the tested interface for their private use. We also collected qualitative measures in form of open questions and log-file analyses.

Participants

Overall, there were 121 participants, 19 to 21 participants in each of the six conditions described above. The sample consisted of 91 females (75%) and 30 males (25%). Participants were randomly assigned to one condition. They ranged in age from 16 to 57, with a mean age of 24.45 (SD = 7.79). 85 participants (70%) were recruited using the participant database of the University of Basel, which consisted of a random population sample. The participants that were recruited via the database were paid CHF 20 for their participation. All of the other 36 participants were undergraduate psychology students from the University of Basel who were given two course credits after having participated. Overall, our participants reported to be familiar with computers (M = 3.31, SD = 0.71, MIN = 1, MAX = 5). 103 participants (85%) also acknowledged that they use the Internet on a daily basis, the other 18 participants use it several times a week. 75 participants (62%) reported to use online banking for private use.

Apparatus and Materials

Apparatus. The study was conducted in the usability lab of the psychology department of the University of Basel. Stimuli were presented on a Tobii 1750 eye-tracking monitor, which was connected to a Windows XP machine with a 45.000 kbit/s internet connection and Firefox 2 was used to access the web interfaces. Tobii Studio 1.2.30 was utilized to gather the eye-tracking data, to guide the participant through the experiment and to present the instructions between the different tasks. Firefox and Tobii Studio run on the same machine. During the experiment, the participant was observed by the experimenter from another room via a video camera. Moreover, sound and the actual screen picture were transmitted to the experimenter’s room as well. By pressing a button, the experimenter was able to speak to the participant.

User Interfaces. According to the 2 x 3 factor design, there were six different versions of the user interface. Basically, they all consisted of the same parts. On the upper left side, there was a box, containing the different filters that enabled to filter down all the available transaction data. The number of transactions, found on the basis of the settings made in the filter box, was shown in a small area beneath the filter box. At the bottom side of the screen, a table displayed the filtered transactions including their corresponding details. In the with chart conditions, a chart on the upper right side displayed the account balance during the time range, participants had set in the filter box. Figure 1 provides an overview of the basic structure of the different user interfaces.

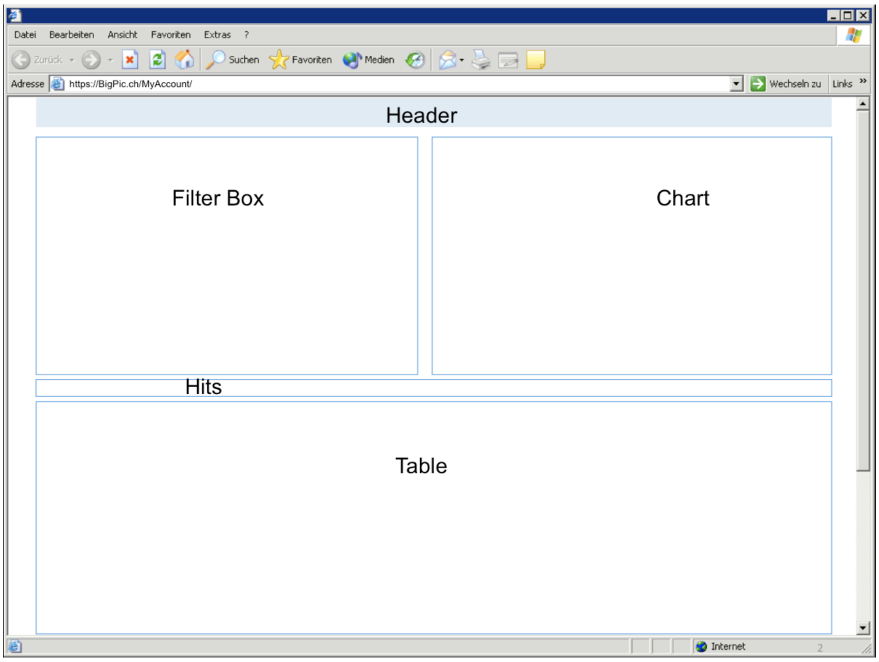


Figure 1. All areas of the interface were influenced by the settings participants made in the filter box (upper left area). The filter box also was the place where the main differences between the conditions of the factor Ajax occurred. Factor chart mainly influenced the area on the upper right side.

Due to the data visualization slider that was used in the Histogram Ajax conditions, the Simple Ajax and the Histogram Ajax conditions looked differently. However, they had similar handling. Figure 2 compares the appearance of the filter boxes of the Simple Ajax conditions and the Histogram Ajax conditions. Clicking on the buttons ("1 month", "2 months", "1 year" or "Max") directly above the date slider enabled the participant to choose the date range, which had to be displayed in the slider area. By clicking on the "Max" button, the maximal time range of two years was displayed in the slider area. If the slider area represented a shorter time range than the maximal time range, the triangles on the left and the ride side of the slider enabled to scroll through the time range, which was displayed on the slider area. When a slider thumb was picked, a box showing the thumb's current value was displayed right above this slider thumb. By dragging the blue bar between the slider thumbs, both of them could be adjusted simultaneously. In contrast to the date slider, the amount slider used a logarithmic scale. Hence, small amount ranges could precisely be adjusted while large amount ranges still could be displayed on the same slider area.

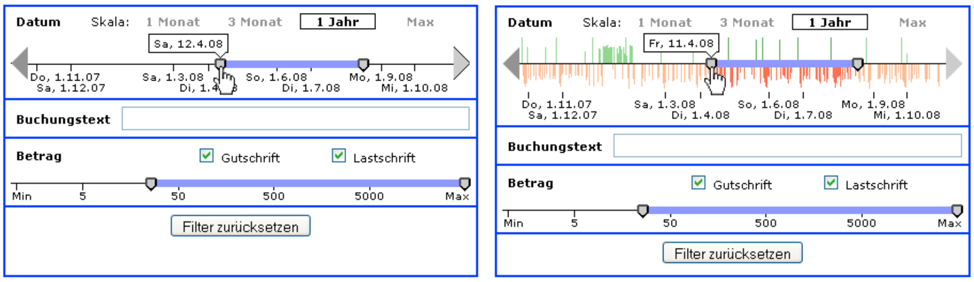


Figure 2. The left side shows the filter box of a Simple Ajax condition while the right side demonstrates the slider box of a Histogram Ajax condition, which uses a data visualization slider to set the date range. On the data visualization slider area credits are represented in green, debits are represented in red.

After the first letter was typed into the search box, the autosuggest feature in the Ajax conditions automatically added a menu to that search box, which enabled one to choose from different search suggestions provided by the system. If a suggested transaction was not located within the adjusted time range, the amount range or the chosen transaction type a red warning was displayed. The warning described the necessary changes to find the suggested transactions. Figure 3 demonstrates the search box and the autosuggest menu.

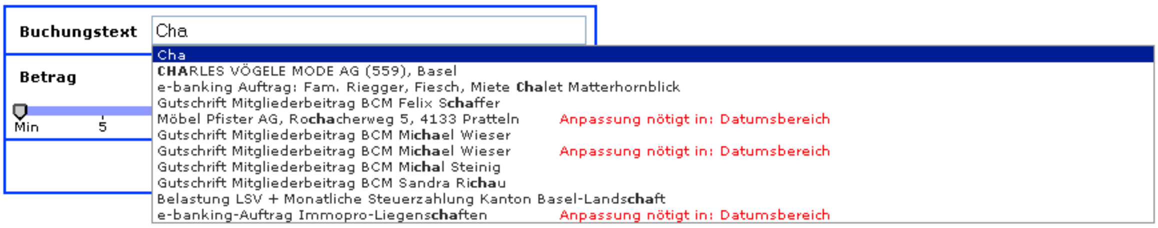
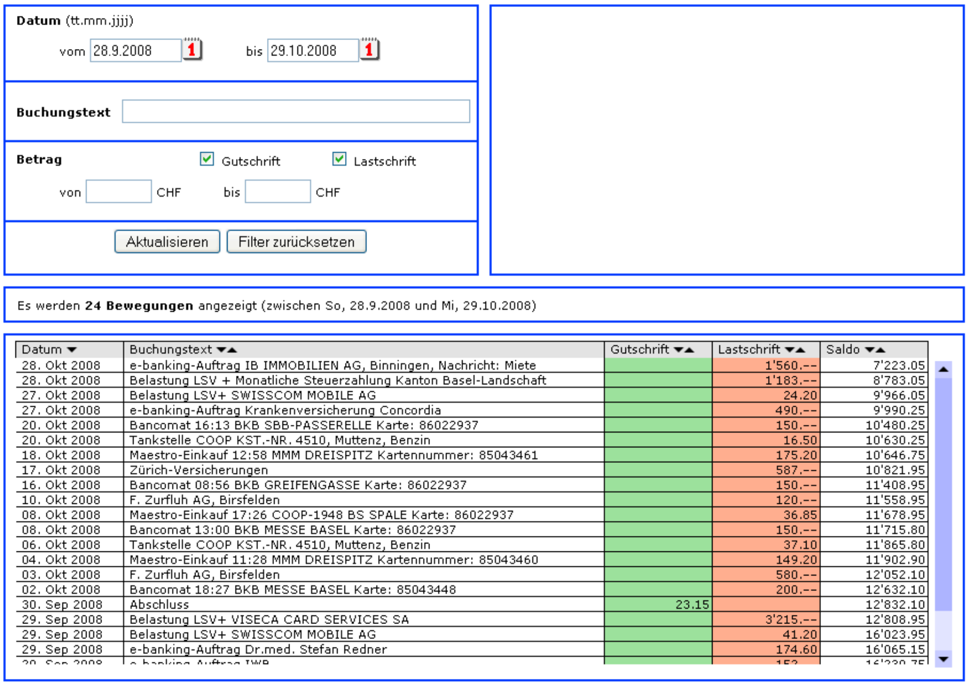


Figure 3. Red warnings were displayed if a suggestion could not be found displayed due to settings made on other filters.

Due to the two stages of the factor chart, there were two conditions with Non-Ajax interfaces, two Simple Ajax interfaces and two Histogram Ajax interfaces. Figures 4 to 9 provide an overview of all the factor stages and their combinations.



Datum	Buchungstext	Gutschrift	Lastschrift	Saldo
28. Okt 2008	e-banking-Auftrag IB IMMOBILIEN AG, Binningen, Nachricht: Miete		1'560.--	7'223.05
28. Okt 2008	Belastung LSV + Monatliche Steuerzahlung Kanton Basel-Landschaft		1'183.--	8'783.05
27. Okt 2008	Belastung LSV+ SWISSCOM MOBILE AG		24.20	9'966.05
27. Okt 2008	e-banking-Auftrag Krankenversicherung Concordia		490.--	9'990.25
20. Okt 2008	Bancomat 16:13 BKB SBB-PASSERELLE Karte: 86022937		150.--	10'480.25
20. Okt 2008	Tankstelle COOP KST.-NR. 4510, Muttenz, Benzin		16.50	10'630.25
18. Okt 2008	Maestro-Einkauf 12:58 MMM DREISPITZ Kartennummer: 85043461		175.20	10'646.75
17. Okt 2008	Zürich-Versicherungen		587.--	10'821.95
16. Okt 2008	Bancomat 08:56 BKB GREIFENGASSE Karte: 86022937		150.--	11'408.95
10. Okt 2008	F. Zurfluh AG, Birsfelden		120.--	11'558.95
08. Okt 2008	Maestro-Einkauf 17:26 COOP-1948 BS SPALE Karte: 86022937		36.85	11'678.95
08. Okt 2008	Bancomat 13:00 BKB MESSE BASEL Karte: 86022937		150.--	11'715.80
06. Okt 2008	Tankstelle COOP KST.-NR. 4510, Muttenz, Benzin		37.10	11'865.80
04. Okt 2008	Maestro-Einkauf 11:28 MMM DREISPITZ Kartennummer: 85043460		149.20	11'902.90
03. Okt 2008	F. Zurfluh AG, Birsfelden		580.--	12'052.10
02. Okt 2008	Bancomat 18:27 BKB MESSE BASEL Karte: 85043448		200.--	12'632.10
30. Sep 2008	Abschluss	23.15		12'832.10
29. Sep 2008	Belastung LSV+ VISECA CARD SERVICES SA		3'215.--	12'808.95
29. Sep 2008	Belastung LSV+ SWISSCOM MOBILE AG		41.20	16'023.95
29. Sep 2008	e-banking-Auftrag Dr.med. Stefan Redner		174.60	16'065.15

Figure 4. Non-Ajax, without chart condition.

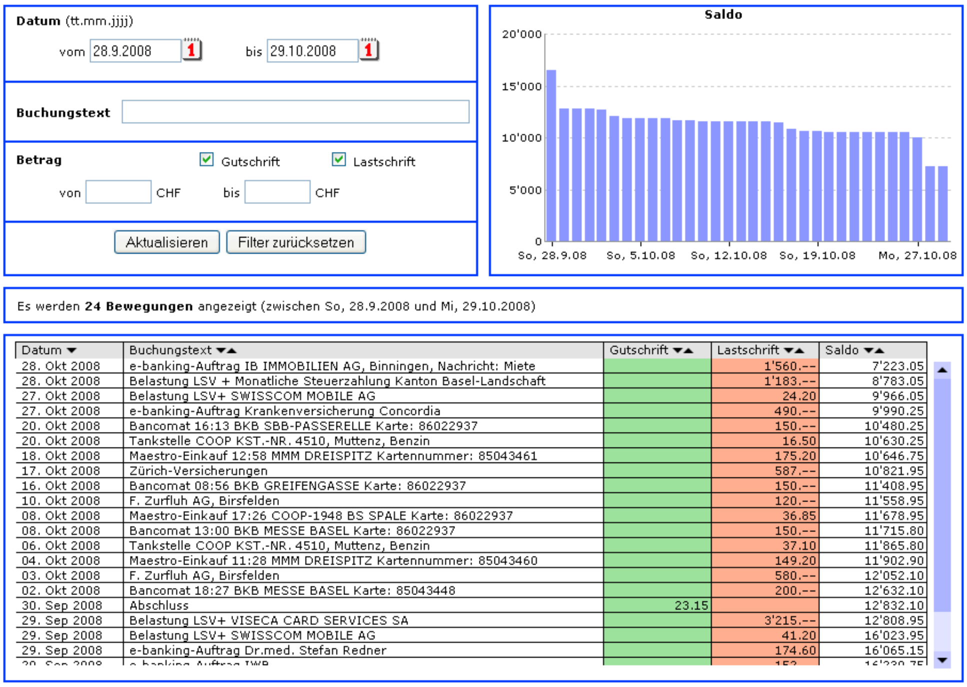


Figure 5. Non-Ajax, with chart condition.

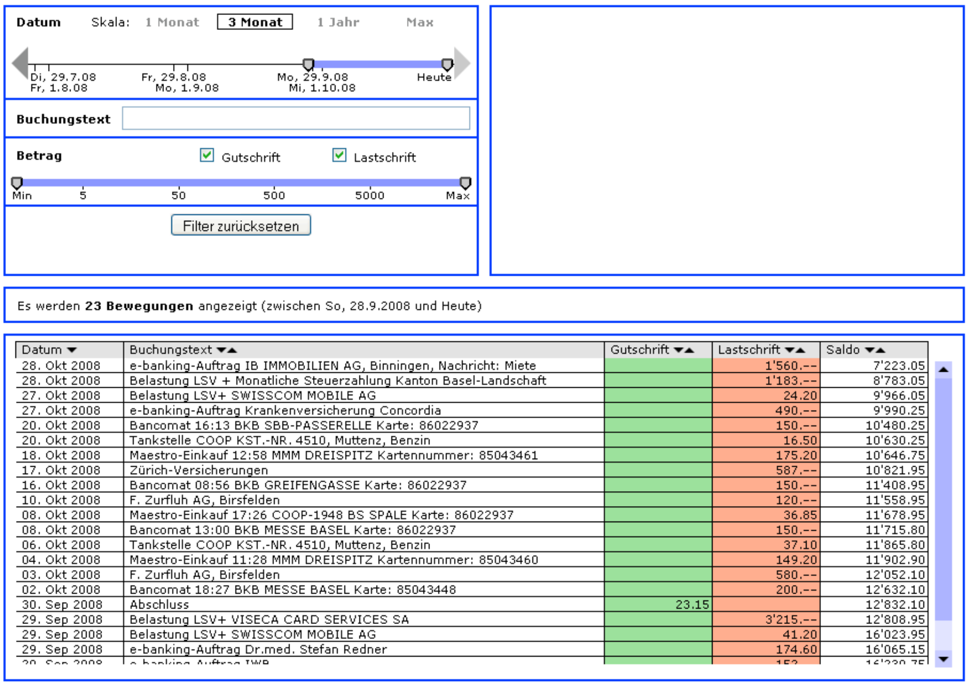


Figure 6. Simple Ajax, without chart condition.

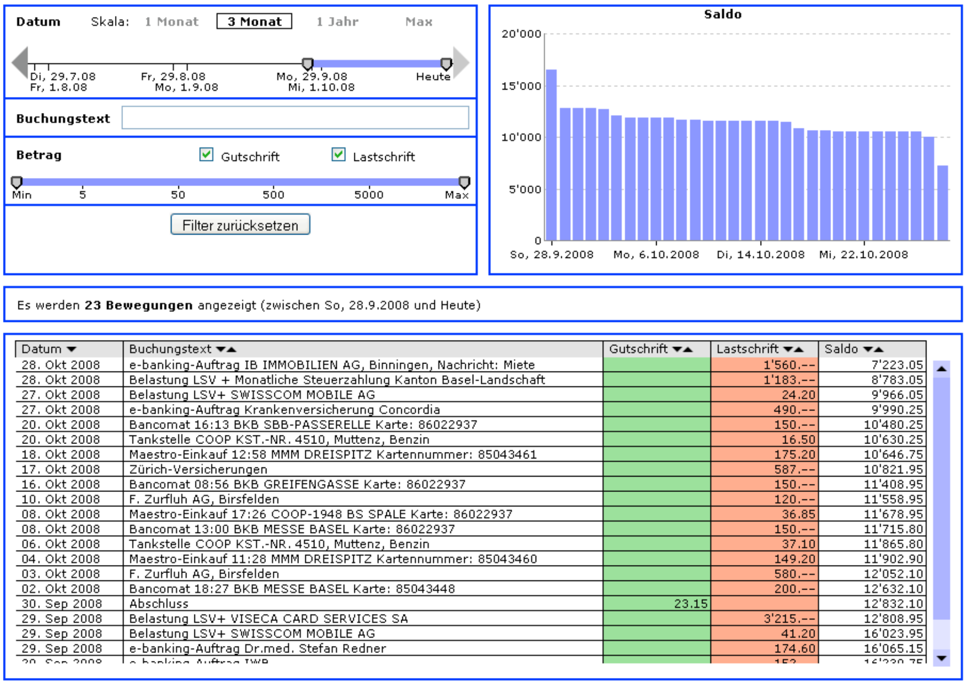


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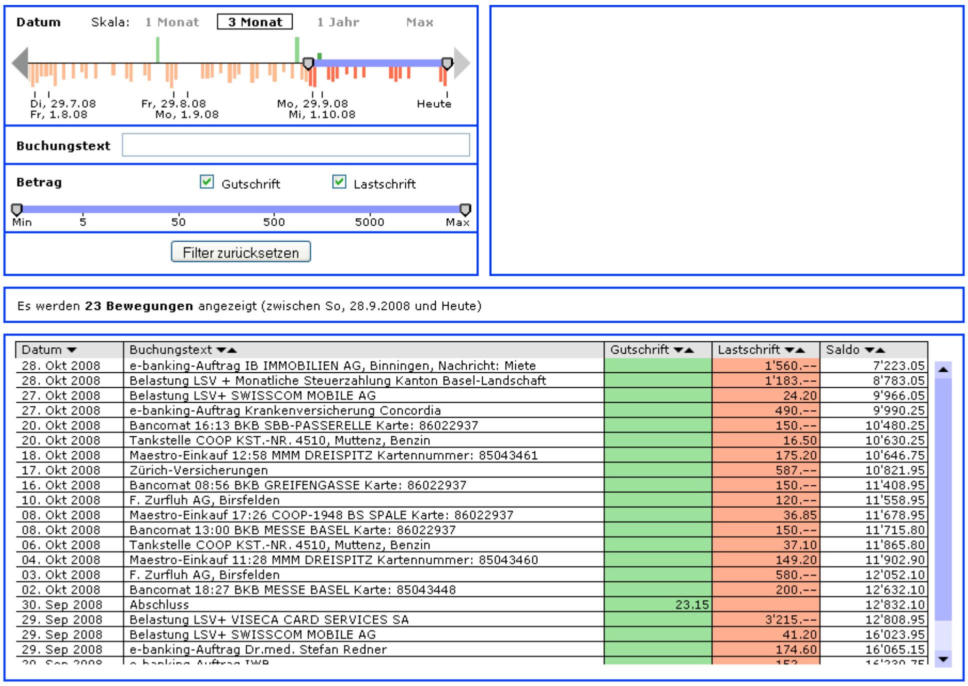
Figure 7. Simple Ajax, with chart condition.



Datum	Buchungstext	Gutschrift	Lastschrift	Saldo
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29. Sep 2008	e-banking-Auftrag Dr.med. Stefan Redner		174.60	16'065.15

Figure 8. Histogram Ajax, without chart condition.

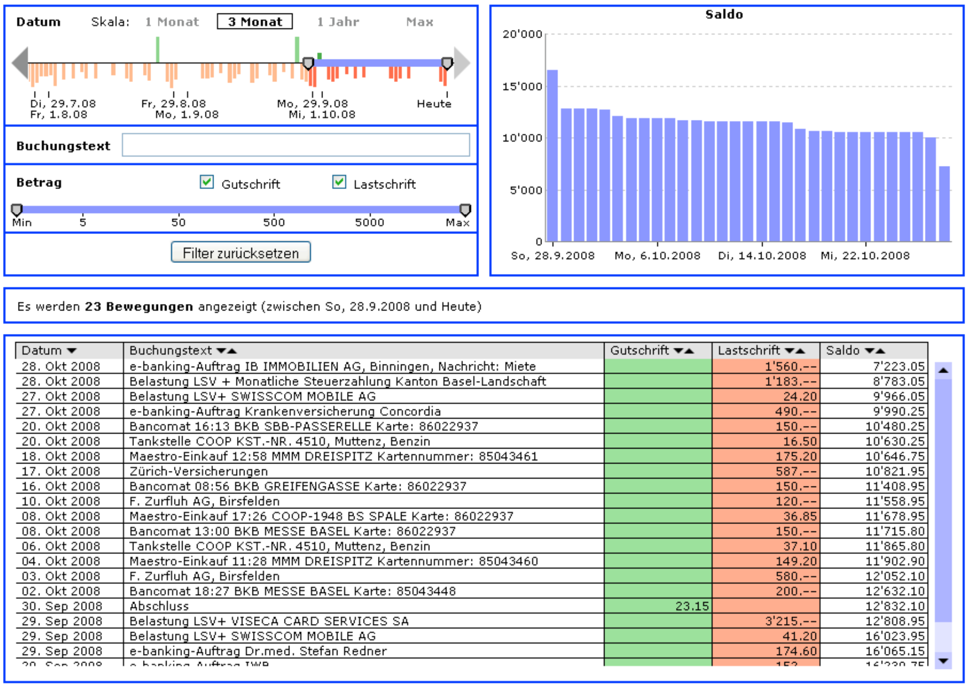

Figure 9. Histogram Ajax, with chart condition.

Guideline and main study. The experiment guideline was printed on paper and was handed out to every participant. Following a brief introduction, it contained the descriptions of all main tasks. Overall, there were seven different main tasks. If a task required an answer, there was space left next to every task to write down the answer directly into the study guideline. Every single task was printed on a different sheet of paper. In order to cope with the tasks, participants had to use a combination of different filter elements (for instance search for transactions with a given text within a particular date range). Table 1 provides an overview on the different tasks that were used in the experiment. A complete description of the task can be found in the appendix A.

Table 1

Description of the tasks used in this study

Task	Description
1	Introductory Tasks
2	Single Element: Use of filter possibilities
3	Single Element: Use of free text field
4	Single Element: Use of the chart
5	Combination: Amount slider and text search
6	Combination: Date slider and text search
7	Control Task for learning effects

Procedure

Participants were tested individually. They were told that they were going to test an online banking prototype's usability and therefore should be critical. After the participants had taken their place in front of the eye-tracking monitor and adjusted their chair, the eye-tracking program was calibrated and the experimenter left the room. Throughout the whole experiment, participants could get in touch with the experimenter sitting in another room observing the participant's screen. In order to complete the study, participants had to work on all four stages of the experiment: a pre-study questionnaire, a think-aloud practice task, the main study and a post-study questionnaire. The pre-study estimated the quality of the participant's computer skills, in particular Internet usage and online banking experiences. Additionally, they were asked about their opinion on online banking and which task was the most annoying they had to deal with while they were logged into their online banking accounts. Afterwards, participants were presented a brief think-aloud practice task. Following the think-aloud practice task, the participants were shown the seven tasks of the main study. These tasks were described in the study guideline that was printed on paper and handed out to the participants. Answers (if the task asked for any) had to be written directly into the study guideline. After the completion of the main study participants were required to complete a post-study questionnaire, which interrogated their subjective opinions on the interface they had tested before.

Results

A two-tailed alpha level of 0.05 was used for all statistical tests. Outliers were detected and excluded using the technique described in Tabachnick and Fidell (2001). Data were transformed into Z-scores and afterwards scanned for univariate outliers. Outliers were excluded individually for each group if they were more than 3 standard deviations apart from the group's mean.

Objective scales

The objective scales consisted of the total number of clicks, the total task completion time, the number of correct answers written into the guideline, the total fixation length of the screen and the total fixation count. As this report merely concentrates on the effects of the factor Ajax, comprehensive descriptive statistics of all six conditions can be found in appendix B. Descriptive statistics of the objective scales, only depending on the factor Ajax, can be seen on table 2.

Table 2

Averaged objective measures, dependent on factor Ajax

Dependent variable	Condition	M	SD	N
Total Number of Clicks	Non-Ajax	143.26	48.88	38
	Simple Ajax	163.52	48.48	36
	Histogram Ajax	155.75	68.05	40
Total Task Completion Time (min)	Non-Ajax	20.35	4.97	39
	Simple Ajax	25.18	6.13	37
	Histogram Ajax	24.87	6.41	40
Correctly Solved Tasks	Non-Ajax	11.67	1.48	41
	Simple Ajax	10.91	1.78	38
	Histogram Ajax	11.02	1.73	39
Total Fixation Length	Non-Ajax	10.31	2.99	39
	Simple Ajax	14.30	3.96	37
	Histogram Ajax	14.94	4.66	40
Total Fixation Count	Non-Ajax	1561.94	438.12	38
	Simple Ajax	1962.31	530.36	36
	Histogram Ajax	1855.68	539.61	38

Note. M = Mean, SD = Standard Deviation.

Data of the objective measures were analyzed using a two-way analysis of variance for unrelated samples, with chart (with chart, without chart) and Ajax (Non-Ajax, Simple Ajax, Histogram Ajax) as independent variables. Scheffé's contrast analysis was used to compare the effects caused by the individual stages of the factor Ajax. In order to calculate the Scheffé contrasts, the with chart and the without chart condition were averaged only if the factor chart had no effect on a dependent variable and if no significant interaction between the factors chart and Ajax was found. Regarding all of the objective scales, we found no significant interactions between the factors chart and Ajax.

Total Number of Clicks. As the distribution of clicks showed a moderate positive skewness, we transformed the data using a logarithmic transformation (natural). The total number of mouse clicks was significantly influenced by the factor chart, $F(2,108) = 5.20$, $p = .03$. The factor Ajax had no significant effect on the total number of mouse clicks $F(1,108) = 1.63$, $p = .20$.

Total Task Completion Time. As the distribution of the total task completion time differed from the normal distribution we transformed the data using a logarithmic transformation (natural). The total task completion time was significantly influenced by the factor Ajax, $F(2,110) = 6.18$, $p = .00$, whereas the factor chart had no influence on the task completion time, $F(1,110) = 1.47$, $p = .23$. Scheffé's contrast analysis showed that it took participants of the two Ajax conditions longer to solve the given tasks than participants in the Non-Ajax conditions ($p < .05$). No difference in the total task completion time was found between the Simple Ajax and the Histogram Ajax conditions (using Scheffé's contrast, $p > .05$). Figure 10 illustrates this finding.

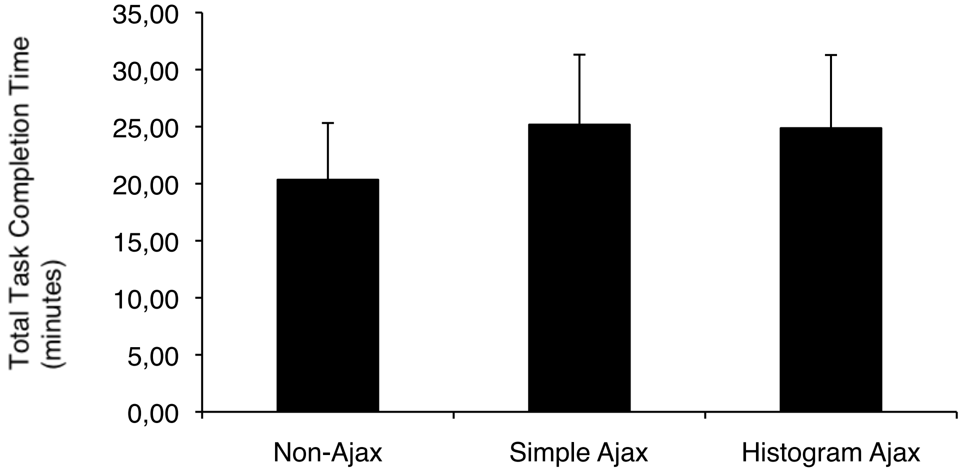

Figure 10. Participants in the Non-Ajax condition were significantly faster than participants in both Ajax conditions.

Correctly solved tasks. For each correctly solved task one point was assigned resulting in a maximum of 13 points that could be reached. 92 % of the participants reached more than 8 points for correctly solved tasks. The factor Ajax did not influence the number of correctly solved tasks, $F(2,112) = 2.35$, $p = .10$. Furthermore, Scheffé's contrast analysis showed no significant differences between the Non-Ajax, the Simple Ajax and the Histogram Ajax conditions ($p > .05$).

Total Fixation Length. The screen fixation length was significantly influenced by the factor Ajax, $F(2,110) = 16.32$, $p = .00$. Scheffé's contrast analysis brought out a similar pattern as it was found at the dependent variable total task completion time: Participants in both Ajax conditions fixated the screen during a longer time period than the participants in the Non-Ajax conditions ($p < .05$). Again, no difference was found between the two Ajax conditions ($p > .05$). Figure 11 illustrates the different fixation lengths depending on the factor Ajax.

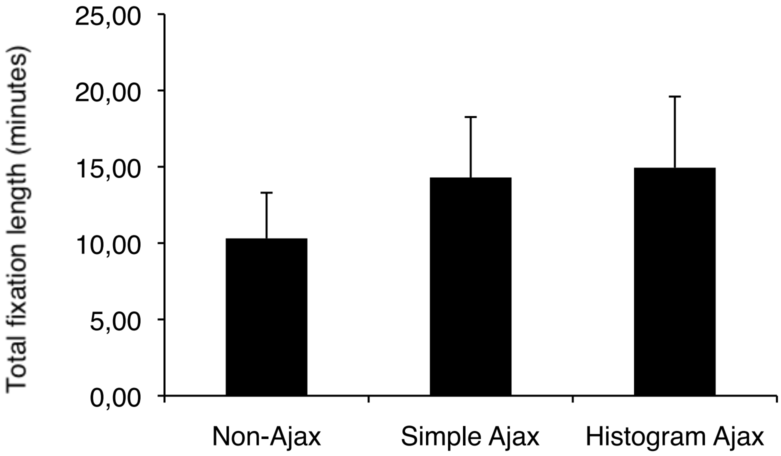

Figure 11. The time during which participants were looking at the screen was significantly longer in both Ajax conditions than it was in the Non-Ajax condition.

Total Fixation Count. Similar to the total fixation length, the total fixation count was significantly influenced by the factor Ajax, $F(2,106) = 6.39$, $p = .00$, whereas the factor chart did not influence the total fixation count, $F(1,106) = 1.52$, $p = .22$. Scheffé's contrast analysis showed no differences in the total fixation count between the Ajax conditions ($p > .05$). Both Ajax conditions had a significantly higher total fixation count than the Non-Ajax conditions (using Scheffé's contrast, $p < .05$).

Subjective scales

Subjective measures consisted of the System Usability Scale (Brooke, 1996), measuring the usability of the interfaces, the NASA-TLX (Hart, 1988), measuring the workload and a simple non-standardized six-point Likert scale that measured the participant's overall impression of the tested interface. After completing these questionnaires, participants were also asked whether they would like the tested interface for their own use or not.

As this report merely concentrates on the effects caused by the factor Ajax, comprehensive descriptive statistics of all six conditions are shown in appendix C. Descriptive statistics of the subjective scales, only depending on the factor Ajax, can be seen on table 3. A comparison of the System Usability Scale ratings our interfaces got from our participants with the values that were specified by Bangor, Kortum & Miller (2008) highlighted that the two Ajax conditions had a usability that lied between "OK" and "good" while the Non-Ajax conditions had a usability that lied between "good" and "excellent".

Table 3

Descriptive statistics of the subjective scales dependent on the factor Ajax

Dependent variable	Condition	M	SD	N
System Usability Scale	Non-Ajax	83.71	13.70	39
	Simple Ajax	65.97	18.89	36
	Histogram Ajax	67.37	16.02	39
NASA-TLX	Non-Ajax	108.59	60.96	39
	Simple Ajax	165.97	87.07	36
	Histogram Ajax	140.38	74.42	39
Simple Overall scale	Non-Ajax	5.18	0.68	39
	Simple Ajax	4.19	1.14	36
	Histogram Ajax	4.15	1.09	39

Note. M = Mean, SD = Standard Deviation.

When data was checked for ANOVA preconditions, all of the subjective scales showed highly significant Levene tests and therefore, were analyzed using nonparametric tests. However, using the Mann-Whitney U test, data was still checked for significant effects caused by the factor chart before the factor Ajax was interpreted. As shown by table 4, factor chart had no significant impact on any of the subjective scales and therefore, was ignored during further analyses of the subjective scales. Hence, both conditions of the factor chart were averaged during the following analyses of the subjective measures. If the factor Ajax had a an effect on a dependent variable, the Mann-Whitney U test was used to compare all stages of the factor Ajax against each other, which resulted in three comparisons per dependent variable.

Table 4

The factor chart did not have any effects on the subjective scales

	Measure		
	System Usability Scale	NASA-TLX	Simple Overall Scale
Mann-Whitney U	1611.00	1695.00	1541.00
Asymp. Sig.	.32	.93	.19

System Usability Scale. Analysis using the Kruskal-Wallis one-way analysis of variance indicated that ratings of the System Usability Scale were significantly influenced by the factor Ajax, $H(2) = 31.68$, $p = .00$. Comparisons of the different factor stages concerning Non-Ajax, Simple Ajax and Histogram Ajax against each other showed that both of the Ajax versions got significantly worse usability ratings than the Non-Ajax versions with $U(41, 39) = 307.50$, $p = .00$ (comparison of Simple Ajax and Non-Ajax) and $U(41, 40) = 297.00$, $p = .00$ (comparison of Simple Ajax and Non-Ajax). The difference between the usability ratings of the Simple Ajax and the Histogram Ajax version was not statistically significant, $U(39, 40) = 734.50$, $p = .65$.

NASA-TLX. Analysis using the Kruskal-Wallis one-way analysis of variance indicated that the NASA-TLX scale was also significantly influenced by the factor Ajax, $H(2) = 9.90$, $p = .01$. People in the Simple Ajax conditions reported to have a higher cognitive workload than people in the Non-Ajax conditions, $U(42, 36) = 446.50$, $p = .00$. In contrast, the difference between the Non-Ajax version and the Histogram Ajax version was not significant, $U(42, 39) = 634.50$, $p = .08$ and the difference between the two Ajax versions was not statistically significant, $U(36, 39) = 566.00$, $p = .15$.

Simple Overall Scale. Kruskal-Wallis H test showed, that the ratings of the simple overall scale were also significantly influenced by the factor Ajax, $H(2) = 24.64$, $p = .00$. Interfaces from the Non-Ajax versions were rated significantly better than interfaces from both Ajax versions, $U(40, 39) = 389.50$, $p = .00$ (comparison of Simple Ajax and Non-Ajax) respectively $U(40, 40) = 372.00$, $p = .00$ (comparison of Histogram Ajax and Non-Ajax). Again, the difference between both Ajax versions was not statistically significant, $U(39, 40) = 741.50$, $p = .69$.

Will to Use the Interface. Participants were asked if they would like to use the tested online banking interface for themselves. Descriptive data stemming from this question are shown on figure 12. The decision of whether to use this interface or not was not significantly influenced by the factor chart, $\chi^2(1, N = 119) = .215$, $p = .64$. In contrast, responses to this question were significantly influenced by the factor Ajax, $\chi^2(2, N = 119) = 12.18$, $p = .00$.

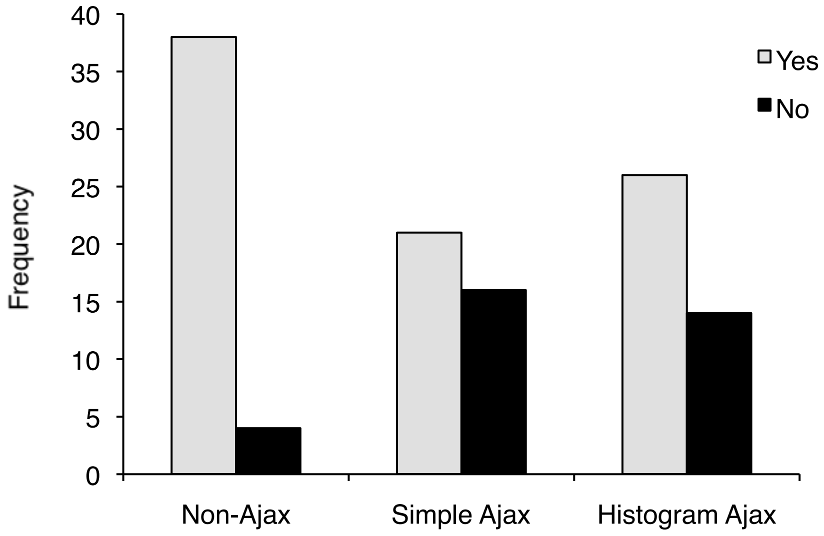

Figure 12. The number of participants who stated they would use the tested interface dependent on the factor Ajax.

Qualitative Data

During the post-study questionnaire qualitative data was also collected. Qualitative data consisted of analyses on the log-entries and analyses of open questions. No inferential statistics were calculated for the qualitative data. Using an open question form, participants were asked to put their subjective opinions in word. For later analyses, all the answers were assigned to one or more of the categories shown in figure 13. Whereas the negative design ratings were not influenced by the factor Ajax, almost every negative entry of the category "Date" stemmed from participants in one of the two Ajax conditions.

Figure 13. Number of Positive and Negative Statements Divided into Fourteen Categories. The overall composition and the handling of the different websites were received as something positive. The design and the date setting mechanism seem to be in need of some improvement.

Autosuggest. To analyze the impact of the autosuggest-feature that came with every Ajax condition, we also analyzed data from the log-files, which was generated on the web-server. In a task at the beginning of the main study, selecting a suggested term led to a too specific search term, which narrowed the results down too much. Participants had to search for *all* transactions that included the letters “MMM”, which is the abbreviation of a discount chain in Switzerland. Payment transactions that were processed in a store of this discounter chain contained of the letters “MMM” plus other information that changed in every transaction. Due to the changing parts of these transactions, choosing one of the suggestions (that always consisted of the entire transaction texts) led to an insufficient amount of displayed transactions. Only 12 of 79 participants (15%) made this mistake. No connection was found between this error and correctly solving the task. Thus, participants recognized the error and could solve the task correctly on a second try. In another task, using the suggestions led to correct results. At this point, 45 of 79 (57%) participants used the suggestions they were presented with. Furthermore, the usage of autosuggest was not forced as there were other ways to solve the task. In cases where the autosuggest feature was used, the search entries we found in the log-files either consisted of less letters or consisted of the complete transaction texts. Shorter search entries were a result of the behavior of the participants to immediately press enter when they saw the searched transaction in the autosuggest list (while they were typing). We found complete transaction texts that were used as search terms when the participants actively chose a suggested transaction from the drop down menu by either pointing on it with the mouse, or by selecting it using the arrow keys.

Discussion

For the most part, the results of our study are consistent with our first two-tailed hypothesis predicting differences in objective and subjective measures between the Non-Ajax conditions and the different Ajax conditions. Compared to the Non-Ajax interfaces, the results of the interfaces that used Ajax enabled techniques could be judged as negative: It took participants from the Simple Ajax and the Histogram Ajax conditions longer to solve the tasks of the main study. We also measured longer fixation times and higher fixation counts in the Simple Ajax and the Histogram Ajax conditions than in the Non-Ajax conditions. According to Pretorius, Calitz and van Greunen (2005), the longer fixation times of the Simple Ajax and the Histogram Ajax conditions can be interpreted as an indicator for their high complexity. Solely the numbers of correctly solved tasks and the numbers of mouse clicks were not influenced by the factor Ajax.

The interfaces that used the Ajax enabled techniques were given worse usability ratings than the interfaces of the Non-Ajax conditions. This was true for all usability scales: The System Usability Scale, the NASA-TLX and a simple non-standardized scale that measured the participants' overall impression of the interface. Different explanations could be used to account for the fact that the Non-Ajax interfaces most scored better than the interfaces that used the Ajax techniques.

Observations made by the experimenters suggest that the bad results of the Ajax conditions mainly are a result of the date slider's usability. The observations suggest, that our participants' major problem concerning the date slider was to realize that the scale, represented on the slider area, could be changed. Another problem was the fact that the date slider was found to be slightly imprecise when large times were represented on the slider area. The participants often were observed while they were trying to enter very precise dates even in cases where the guideline explicitly stated that dates do not have to be specified precisely. Apparently, the possibility to enter an absolutely precise date range in online banking interfaces is a strong user need that must be accounted for. An alternative explanation of the bad results of the Simple Ajax and the Histogram Ajax conditions could be the fact that dynamic querying and autosuggest never were used in online banking before and therefore probably were unfamiliar and unexpected to the participants in this context. This finding is in accordance with the findings of Weir et al. (2007). Similarly to their study, our participants favored using well-known ways to enter data over using more modern ways to interact with the online banking interface. The finding that the total number of mouse clicks was not affected by the factor Ajax, may have been caused by the small calendars that were available in the Non-Ajax conditions and that were not efficient to use mainly if dates had to be selected, which lied several months back in the past (open the calendar, “scroll” to the desired month, choose a date). These calendars were used surprisingly often and may have increased the click rates of the Non-Ajax conditions. Moreover, the factor Ajax did not influence the number of correctly solved tasks, which can be explained by the fact that participants in all conditions solved the tasks very well at the end - although it took them varyingly long times to complete and caused different perceived workloads.

Observations made by the experimenter suggest that the amount slider, which used a logarithmic scale, caused fewer problems than the date slider did. We attributed this to the fact that the amount slider’s scale, which was represented on the slider area, could not be changed and therefore was easier to understand.

Qualitative data from the log-files and from observations suggest that the autosuggest feature was used relatively problem free and the drop down menu, which appeared automatically, did not confuse the participants. Participants could also distinguish such cases in which the use of a suggestion, provided by the autosuggestion, led to wrong results from cases in which it was appropriate to choose one of the suggested items. Autosuggest caused shorter search entries, or (in cases where a suggestion from the list was chosen) more precise search terms that in turn resulted in a smaller number of transactions displayed on the table. Therefore, fewer transactions had to be scanned by eye. To summarize, we interpreted the effect of the autosuggest feature as positive, but not strong enough to countervail the negative effect of the date slider, which was used in the Ajax conditions as well.

Contrary to our second hypothesis, participants in the Histogram Ajax conditions did not perform better than participants in the Simple Ajax conditions. Moreover, the Histogram Ajax interfaces did not get significantly better usability ratings than the Simple Ajax interfaces. However, we found a (not statistically significant) increase in nearly all of the objective and subjective scales, which is worth keeping in mind. Relying on observations of the participants, we attributed this slight increase to the usage of the data visualization in the slider area as a tool - indicating the date scrolling speed when the triangles on the left or the ride side of the slider area were pressed. The visualized data on the slider area was also sometimes used as a tool that indicated at first glance how large the date range was, which was represented in the slider area. Due to the fact that the data visualization on the slider area added another visual element to the interface, the Histogram Ajax conditions may have been perceived as more complicated than the Simple Ajax conditions. This would be in accordance with the findings of Karvonen (2000) that stress the importance of visual simplicity on usability.

Limitations

Dynamic querying and autosuggest only existed as a bundle, which made it hard to analyze these techniques independently from each other. Additionally, although the study was conducted using a high-end computer, the processor sometimes seemed to be overstressed while Simple Ajax or Histogram Ajax interfaces were tested. The excessive processor load, caused by the combination of Ajax enabled techniques and the program that gathered gaze data, led to longer loading times. To sum up, without technical problems, the Simple Ajax and the Histogram Ajax conditions eventually could have done better on the measured objective and subjective scales.

Conclusion

Overall, we found Ajax-enabled interaction patterns to have a bad influence on usability in the context of online banking. Our data suggests that this was mainly because of the usage of dynamic querying to set a date range. We argue that other Ajax-enabled interface elements, such as dynamic querying to set an amount range and especially autosuggest to search for specific transaction texts, can have a positive influence on usability of online banking interfaces. However, more investigations need to be conducted in order to assure the positive effects of these interaction patterns in the context of online banking.

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