

# Visualisation of the Account Balance With a Bar Chart

## The Influence on Table Search

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### Abstract

Technological developments in the Internet are confronting different branches, also online banking. To improve learning, instructional psychology established using pictures. The aim of this study was to connect those fields of research and test the influence of a bar chart containing the information of the account balance and input fields using new technologies in a online banking interface. 121 participants solved seven different tasks on six different interfaces on an eye tracking computer.

Results indicate that the chart neither has an influence on objective measures such as the amount of correctly solved tasks, nor the total completion time or task completion time. Also the subjective ratings of the interface show no significant differences. However, using interface versions with an interactive chart, participants needed less clicks to solve the tasks and showed a lower number of fixations and a lower fixation length on the table area displaying the account data. This implicates a less exhausting search within the table.

### Online Banking, Technological Advances and Visualisation

Online banking was one of the emerging technologies and one of the inventions that has brought additional convenience to the daily life of Western countries since the late 1990s (Hughes, 2003; Weir, McKay, & Jack, 2007). Online banking can be seen as one of the primary success stories of the Internet. It allows users to access their banking data via the Internet and to perform common banking transactions such as paying bills, transferring funds, downloading and printing statements from their home computer (Tan & Theo, 2000; Weir, Douglas, Carruther & Jack, 2009). One aim of the bank is to provide the customer online with a high quality offer that resembles the one to one services at the counter (Khan, Mahapatra & Sreekumar, 2009). Current figures show that in 2008 24 Mio people in Germany used online banking which means that 38 % of all inhabitants between 16 and 74 years use online banking (Heise.de, 2009). Ever since the introduction of online banking there have been conducted studies concerned with the acceptance of online banking in different countries (Tan & al., 2000).

Users like to be in control over their money and the services they use; they want more functionality and convenience for their routine tasks, they want good deals and are increasingly demanding better usability (Weir, Anderson & Jack, 2006). The scientific research focus lies on a comparison of login procedures, e.g. the use of tokens or password and code lists as well as in the interface design and usability of the interface (Weir & al., 2009). Weir et al. (2006) e.g. compared the usage of different language styles within an interface showing that for transaction a form filling metaphor was evaluated as more usable than a spreadsheet metaphor. Banks are trying to get the customer the best possible service by improving their existing interface and eliminating current usability problems (Hughes, 2003; Khan & al., 2009; Weir & al, 2009). They see that what is good for a customer is also good for business and are in favour of applied research (Weir & al., 2009).

In Switzerland online banking was first introduced more than ten years ago with the Direct Net of Credit Suisse (Credit Suisse emagazine, 2007). Almost every bank has since then developed or adopted their own online banking interface (see demo versions of e.g. Postfinance, BKB, ZKB, Credit Suisse, 2009). There have been continuous improvements and enhancements of the interfaces. Stimmt AG for instance has conducted user-centred redesigns of online banking interfaces for several Swiss banks and also Zeix AG has published a report out of the testing lab that they later published in the NZZ newspaper (Zeix, 2003; Stimmt AG, 2009). Concerning technological aspects, there have not been any recent significant changes in the Swiss online banking market though. Here we wanted to close a gap and investigate if new technologies could be integrated into the online banking interface design and if additional features such as a bar chart showing the account's balance would provide a benefit for daily tasks.

However, the online banking sector is responding to new technologies at face pace (Weir & al., 2006). One of the developments to which banks have to react is the recent change happening in the Internet. These changes can be divided into social and technological aspects (O'Reilly, 2005). The social aspects concern the participation of the user in generating content on websites such as in form of texts in blogs and wikis, photos on flickr.com and films on youtube.com. As an example of the technological trends dynamic programming can be mentioned. One prototype of the dynamic programming is Asynchronous JavaScript and XML (Ajax). Paulson (2005) characterizes Ajax as a mixture of old and well known technologies under a new name. Due to Ajax and similar technologies, Internet applications now resemble desktop applications to a greater extent. Reactions to user input within a website are much more instantaneous and users can easily modify online content within the browser. For instance: it is no longer necessary to reload the whole page in order to display the input of an additional text. Other examples can be found on Google. The autosuggest feature displays suggested terms and updates them as additional letters are typed

(Google.com, 2009). In Google maps, updates of new parts of the screen occur smoothly and the image appears to move (Paulson, 2005).

Medicine, learning and marketing were influenced by these developments (Garrett, 2005; O'Reilly, 2007; Paulson, 2005) and many companies have tried to get onto this new wave and to adopt and improve their websites using these new technologies. Soon it had expanded into e-commerce where the integration of the new technologies is being praised as a simplification for the whole shopping process (Miller, 2005). For customers it has become naturally that adding a product into the shopping card can also be done without a page reload or a long waiting time. Online banking has a lot in common with e-commerce as it is a trade of a product and it provides the company with a cheap channel for interaction with the customer (Hughes, 2003).

Still the technological development raises questions for banks providing online banking. Like every sector they face the question whether to implement Ajax based technologies into their interfaces or not and if so to what extent. The Deutsche Bank Börse has conducted research with Ajax technologies and tested new interface solutions. Results are promising as for the search within bonds the Ajax interface was the fastest; there was no need to exit the context and it provided more operation convenience. In a next step they will try to identify more areas of the interface where Ajax technologies could be implemented in addition to the search functionalities (fin.kom, 2007).

The search field is one of the prominent features within the online banking interface. Generally, typical online banking interfaces are very similar in their appearance (see demo versions of e.g. Postfinance, BKB, ZKB, Credit Suisse, 2009). The interface usually displays information of the account data such as account balance, credits and debits. It also includes functionalities to initiate transactions and a search functionality to search for amounts, dates and transaction statement texts. The input fields for the search and the display of the results are mostly placed on two different screens implying that at least one page reload is needed to

change between the input and the output. Searching a certain transaction often results in an extensive amount of data displayed in a table on either one or several screens. The user then has to browse this output in order to spot the required information. This is an exhaustive process and the user has to scan every entry of this potentially large amount of data.

Shah, Freedman & Vekiri (2005) outline that humans are not made for processing large amounts of data. Hence, from time immemorial humans have tried to use visualisation as a mean of external cognition. Examples are cave paintings or the map of Napoleon's crusade towards Russia. The visualisation of large amounts of abstract data is prevalent in different research fields. In their work Shah et al. (2005) lined out that much research has been going on in the area of information visualisation.

A main goal of information visualisation is to find new possibilities and new visual metaphors to represent visual data and combine it into interfaces (Gershon & Page, 2001; InfoVis.org, 2009). According to Card, Mackinlay and Shneiderman (1999) information visualisation is the use of computer-supported, interactive visual representations of abstract data in order to amplify cognition. Information is being transformed to enable the user to observe, browse, make sense and understand it (InfoVis.org, 2009). The visual system then perceives and processes this pre-processed data. One interesting field where this research finds its application is the learning and knowledge acquisition of abstract data (Shah et al., 2005). Three main fields are business and medicine, computer science and teaching and learning. Business and medicine are trying to influence customers' and patients' decisions by appropriate interpretation of graphs, for example when they buy something or have to choose the correct medical treatment. Computer science and the field of interaction design have tried to develop automated display systems and novel information visualization tools that are partly based on the cognitive models of graph interpretation. For the educational sector it has been important to focus on errors that students make and on how to teach them graphical literacy skills. The inaccurate interpretation of a graphical display can even lead to serious problems

such as the Challenger disaster in 1986 (Shah et al., 2005). The analysis of the disaster revealed problems when interpreting the supplied charts and diagrams to make necessary decisions (Tufte, 1997).

While surfing the Internet or working with offline applications we encounter different kinds of visualisation such as pictures, maps and diagrams. The use of a pictorial feature in form of charts and diagrams in addition to text is one mean of visualisation. Research concerning the use of pictures in different implementation fields has a long history. Paivio (1971) already stated that pictures were superior to text and formulated the dual coding theory. This theory postulates that there are two different modalities or cognitive subsystems with different underlying coding mechanisms. This theory has been challenged in recent years but there has remained a certain interest in the research of pictures, images, graphs and diagrams (Amrhein, 2002). Numerous studies have shown that students can gain more knowledge when learning from text and pictures than from text alone (e.g. Ainsworth, 1999; Mayer & Moreno, 2002). Danserau and Simpson (2009) for example analysed the adoption of visual displays in therapeutical settings showing that organization charts and data flow displays improve the dialog with patients and Brotherstone, Miles, Robb, Atkin and Wardle (2009) showed the impact of illustrations on public understanding of the aim of cancer screening. This study from the background of health care especially looked at the illustration of medical information leaflets and could show that the use of pictures improved the understanding and the attitude of people towards preventive medical checkups for bowel cancer.

In the early stages the results of research with pictures and graphical representations of information have found access to the multimedia instruction and learning (Chandler & Sweller, 1991). There has been done research concerning the visualisation of complex processes and abstract data in multimedia learning. Applied visualisations have become more and more interactive and the user can directly observe the consequence of a manipulation. As

an example Bodemer, Ploetzner, Bruchmüller and Häcker (2005) cite the gradual deceleration of a bike during the interactive application of a brake lever. The animation is running after the manipulation of an input variable like the lever. They state that the conceptual model has to be inferred by the learners in process of discovery learning. Tversky and Bauer Morrison (2002) though mention that not all graphical representations are effective in all situations. They also discuss the usage of animated graphics in order to be able to integrate the aspect of time into an already complex graphical representation. The research on the application of animated representations is not yet very promising for teaching complex learning material from the mechanical, biological and computational background (Tversky & al., 2002). Rasch and Schnotz (2009) found evidence that there are task-appropriate graphics, which can support learning, but there are also task-inappropriate graphics, which can conflict with the construction of mental models.

Cognitive load theory is another important aspect to be mentioned in the context of the research of the use of graphics (Chandler & al., 1991; Sweller, Merrienboer & Paas, 1998). One main focus has been on the dependency of the learning material and the amount of cognitive load in multiple representations. Different presentation modes can induce different amounts of subjectively experienced load on working memory. In a study where they compared learning and comprehension from learning cards, Eilam and Poyas (2008) could show an advantage for multiple representation (graphic and text) cards compared to simple text-only cards. A possible explanation for this effect could be that colours and the variety in the multiple representation cards enhanced the motivation of the students and this in turn amplified the knowledge acquisition (Eilam et al., 2008). The split attention theory on the other hand states that if picture and text are presented simultaneously but the information has to be integrated from the user it places a greater cognitive demand on the working memory of the user. This results in an increased workload (Sweller et al., 1998; Mayer & al., 2002). Further studies showed that animations place greater cognitive demand on the learner than



static pictures as well (Ayres & Paas, 2007). On the basis of the mentioned research in completely different research contexts it can be concluded that results hold good for pictures in different kinds of instruction (Skorge, 2005).

Graphical displays have become more important and people are more often confronted with graphs in the daily life. In the Internet, the new technologies allow for more elaborated graphical representations that people have to work with and relying on for decisions. Also in the context of searching and queries good data visualisation is used and recommended (Alberg, 1992). So far though there has not been much research on the usage of pictures or graphical elements in applied domains like online banking. Only one bank account includes some kind of graphical representation of the account's balance. The Postfinance interface includes an option to either present the account's balance as a line chart or a textual representation (Postfinance, 2009).

The aim of this study is to evaluate the use of new Ajax technologies in an interface of the online banking context on the one hand and to evaluate an eventual benefit or disadvantage of an interactive chart of the account balance in the same interface on the other. The results of our study could help the practitioners decide, whether to use some kind of interactive graphical representation within an online banking interface once a secure Ajax-framework has established. Additionally it should give the research within the field of the usability of online banking new input and show if customers are really reluctant to adopt new features as suggested by Weir et al. (2006). We therefore compared six different interfaces, which differed regarding to the usage of Ajax technologies and of a chart. To test if the interfaces differ in terms of different dependent variables we measured objective measures such as task completion time and mouse clicks but also subjective ratings for the experienced usability, general impression on likert scales and the cognitive load. Additionally the influence on fixation length and number of fixations of particular areas of the screen could be analysed using eye tracking data.

The interfaces differed in terms of the input possibilities for the search fields concerning the date, transaction statement texts and amount. All conditions were equipped with an input field for the date, the transaction text and the amount of the transaction. Non Ajax conditions included an input field using the standard 'click and reload' mechanism. The remaining four conditions used Ajax, meaning that there was no reloading of the page necessary to see the results. Condition three and four were the Simple Ajax conditions where the date search and the amount search were replaced by a slider bar. The Histogram Ajax conditions differed from the simple one only that there was a further illustration included in the date slider to illustrate the amount of transaction executed at a certain date. For each of the three versions we developed an interface with and one without chart as graphical representation of the account balance.

This work will primarily focus on the analyses and interpretation of the influence of the chart and evaluate the benefit or the possible drawbacks of the chart in the online banking context and the interface. The influence of the Ajax technologies are evaluated and discussed in the master thesis of Lorenz Ritzmann (2009).

### *Hypotheses*

As the benefit of an additional representation of a data amount could be shown in different areas (Mayer et al., 2002; Brotherstone et al., 2009), we expect to see a difference regarding the measures of time and the amount of mouse clicks between the conditions with and without interactive charts. We expect the conditions with charts to outperform the conditions without chart.

The usage of eye tracking to evaluate the usability of screen layouts has been established and provides insight into where users are looking, additionally to the log file recordings and thinking aloud protocols. The eye tracking data measures normally used are the fixation counts and the fixation lengths within certain areas of interest (AoI). The number of fixations is negatively correlated to the search efficiency; large figures representing a less

efficient search. One reason for longer search times might be poor arrangement of the elements within the interface. Long fixation times can indicate the complexity and difficulty of a screen (Pretorius, Calitz & Van Greunen, 2005). The number of fixations within a certain AoI gives information about the relative importance of one interface element. We expect the eye tracking data to reflect the use of the charts and the interfaces with chart to show a smaller number of fixations within the table area.

The research on the interactivity of charts for example showed that interactive animations could sometimes support and improve the comprehension and learning of material more than static pictures (Tversky & al., 2002). We expect participants to use the interactive functions of the chart at least in one of the assigned tasks.

Studies in the field of multimedia learning imply an increased cognitive load if a chart is redundant and adds no value for solving the tasks and the user's attention therefore has to be split between text and the graphical representation (Sweller et al, 1998). On the other hand data suggests a decrease of cognitive load if a graphical representation helps to find the requested information and thus facilitates the solving of the task (Eilam et al., 2008). Those studies however worked with learning material from technical contexts, like for instance the blood flow through the heart (Sweller & al., 1998). We therefore hypothesise the subjective cognitive load to be different in the condition with chart compared to the one without chart.

## Method

### *Participants and Design*

*Design.* For this study we used a between subject design. The independent variables chosen were the factors chart with two levels (with or without chart) and the factor Ajax with three levels (Non-Ajax, Simple Ajax, Histogram Ajax). This resulted in a 2x3 design with six different experimental conditions. The difference between the Simple Ajax and Histogram Ajax was an additional feature of a histogram included in the date filter. We selected

dependent measures to evaluate the usability of the interface on three different levels like effectiveness, efficiency and satisfaction (ISO 9241, 1998; Hornbaek, 2006). Task completion rate was used as an effectiveness measure, total completion time, task completion time and the number of clicks to measure efficiency and satisfaction was measured using ratings for subjective satisfaction with the interface and ratings of the System Usability Scale (SUS) questionnaire (Brooke, 1996). In addition, participants filled in the NASA Task Load Index (NASA-TLX) (Hart, 1988) to measure the experienced cognitive load. We conducted the study as individual tests in the laboratory, recording eye tracking data, such as fixation length and number of fixations of different screen parts, for each person. For the analysis and interpretation this work will focus on the factor chart. As previously mentioned, information and analyses concerning the factor Ajax can be found in the master thesis of Lorenz Ritzmann (2009) as the complementary work.

*Participants.* 121 participants took part in the study. They were recruited using the participant pool of the Institute of Psychology, University of Basle, and were either given course credit or were paid twenty CHF for their participation. The age of the participants ranged from 16 to 57 ( $M= 24.45$ ,  $SD= 7.79$ ). 91 females (75%) and 30 males took part. 61 % of the participants were students or went to school; the other participants had finished their education. All participants rated their computer and Internet knowledge as good and 103 participants used the Internet on a daily basis, 18 several times a week. An overview of the means of the knowledge questionnaires can be found in Table 1. The data suggests that all participants of this study were experienced in handling a computer.

Table 1.

*Summary of Participant's Demographical Data*

|                           | M (SD)      |
|---------------------------|-------------|
| Computer knowledge        | 3.31 (0.71) |
| Internet Knowledge        | 3.50 (0.77) |
| Online Banking Experience | 2.25 (1.18) |

*Note.* M=mean, (SD = Standard Deviation)

75 participants used online banking at home and more than 50% logged into their bank account several times a month up to once a week. The participants were randomly assigned to one of the six experimental conditions. This resulted in 19 to 21 participants per condition. We had to exclude 10 participants from the analysis because the recordings of their eye tracking data was not sufficient due to technical reasons such as participants leaning too close towards the screen.

*Apparatus and Materials*

*Computer.* The study was conducted in the Usability Lab of the Institute of Psychology in Basle. The participants performed the tasks on Firefox 2.0.0.20. A PC (Intel Pentium, 2.66 Ghz) connected to a Tobii Eyetracker 1750 was used running the Tobii Studio Eye tracking Software 3.0 to record the gaze data of the participants. The main instructions were programmed on the Tobii Studio Software.

*Study guideline.* The study guideline included detailed instructions for all seven tasks. Participants were asked to write down the tasks' solutions in the study guideline on an answering sheet.

*Questionnaires.* The questionnaires used were programmed online and data was recorded in a database. All questionnaires can be found in Appendix A. A pre-study questionnaire included demographical data, questions about the computer and Internet skills of the participants followed by questions about their effective usage of the Internet and online

banking. At the end of the pre-study questionnaire, participants were asked about the experience with the online banking interface they currently use. They had to indicate the tasks they performed most frequently and the task that was the most annoying or caused the most problems. A post-study questionnaire contained a 6-point likert scale with ratings of the used interface on the dimensions general impression, comprehension, overview, organisation or layout and design. This rating was followed by the ten questions of the SUS (Brooke, 1996) translated into German and adopted to online banking. The open comment fields asked for the pros and cons concerning the use of the tested online bank interface and prompted for problems participants had encountered while solving the tasks. All questions had an additional answer option if participants did not want to answer the question. The ratings about experienced cognitive load were collected using an online version of the NASA-TLX (Schmutz, P., Tuch, A., & Opwis, K., 2008). The explored dimensions were mental and physical load, experienced time pressure, own performance, effort and frustration.

*Interface.* The tested interface was designed as a prototype, programmed solely for this purpose and contained fictitious data of an online banking account. To be able to integrate the needs of online banking users we conducted nine interviews prior to designing the interface. The results implied that people are the least satisfied with the payment functionalities and searching possibilities within the online banking interface they use for their finances. Thus, we concentrated on the searching functionalities and developed an interface whose layout was similar to the advanced search interface of Weir et al. (2007), meaning we decided to integrate all available information mentioned earlier on into one screen and allowed sufficient space for a chart. The screen included the main functionalities and elements of an online banking interface and consisted of four main parts as shown in Figure 1.

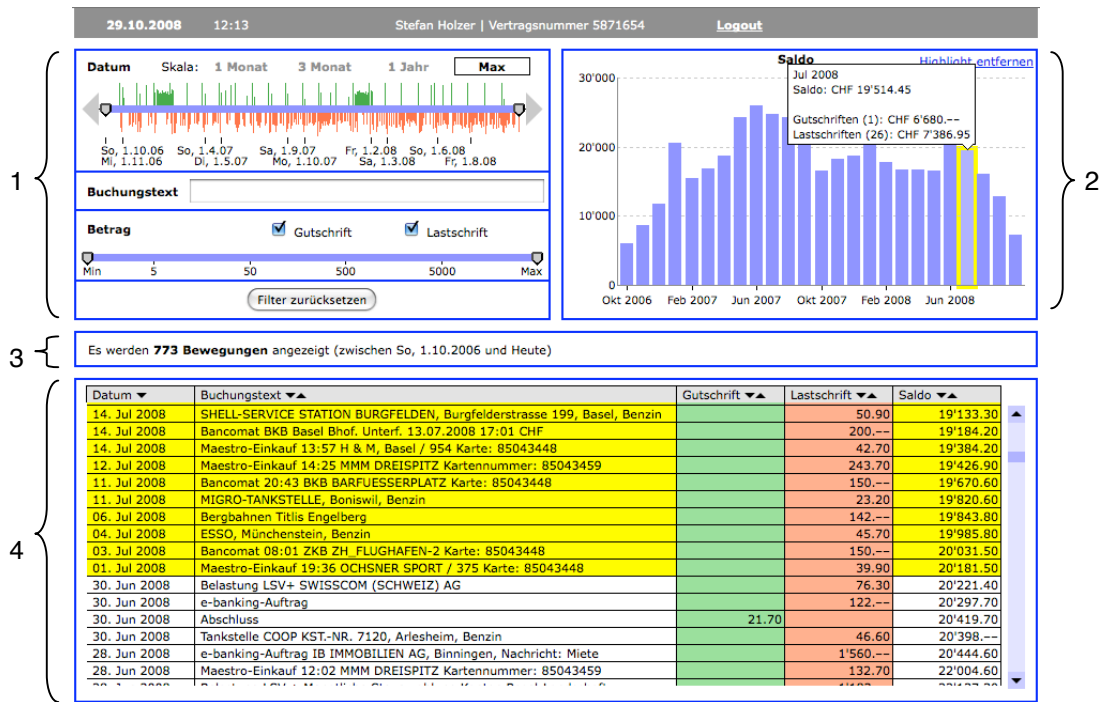


Figure 1. Screenshot of condition 6 (Histogram Ajax with chart) displaying the different interface elements: filter box (1), chart (2), summary of applied filters (3) and table (4) showing the results of the query.

The filter box (1) includes filter options for the date, the value of the debit or credit and a search field to search within transaction statement texts. The filters were either a non Ajax solution including input fields and a ‘Aktualisieren’ (actualise) button resulting in a page reload or Ajax based without page reload including a slider for the date and the amount and a autosuggest text field. Next to the filter box there was a free space where the interactive chart (2) was displayed in three conditions. The bar chart displayed the account balance over the selected time period. The functionalities were identical for all conditions. Moving the mouse over a bar resulted in a tooltip appearing which displayed date, account balance and amount of debits or credits. Clicking on any bar resulted in a yellow highlighting of the bar and the associated entries in the table. In the centre of the screen the number of correct search results was displayed followed by the summary of the applied filter settings (3). A table (4) at the bottom of the screen consisted of five columns for date of the transaction, details of the financial transaction, amount of the transaction divided into credit and debit and account

balance. The table was identical in all conditions. Figures 2 – 7 illustrate the six different used interfaces.

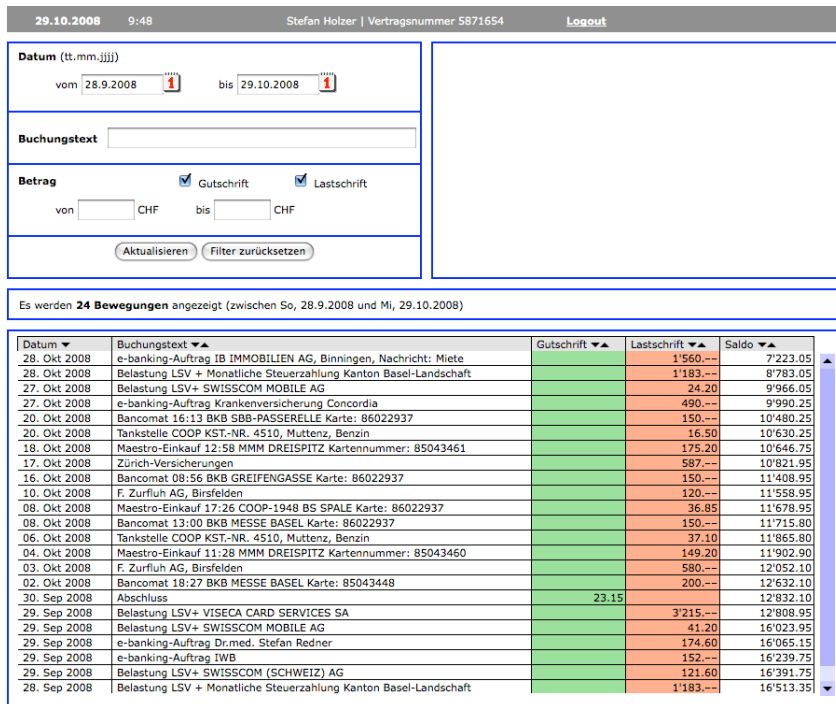


Figure 2. Condition 1: Non-Ajax, without chart.

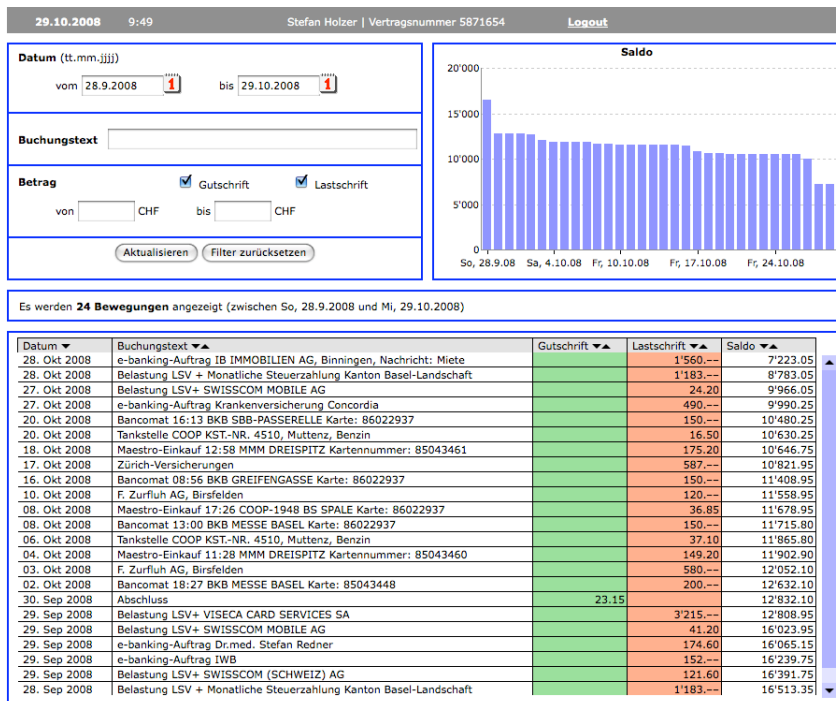


Figure 3. Condition 2: Non-Ajax, with chart.



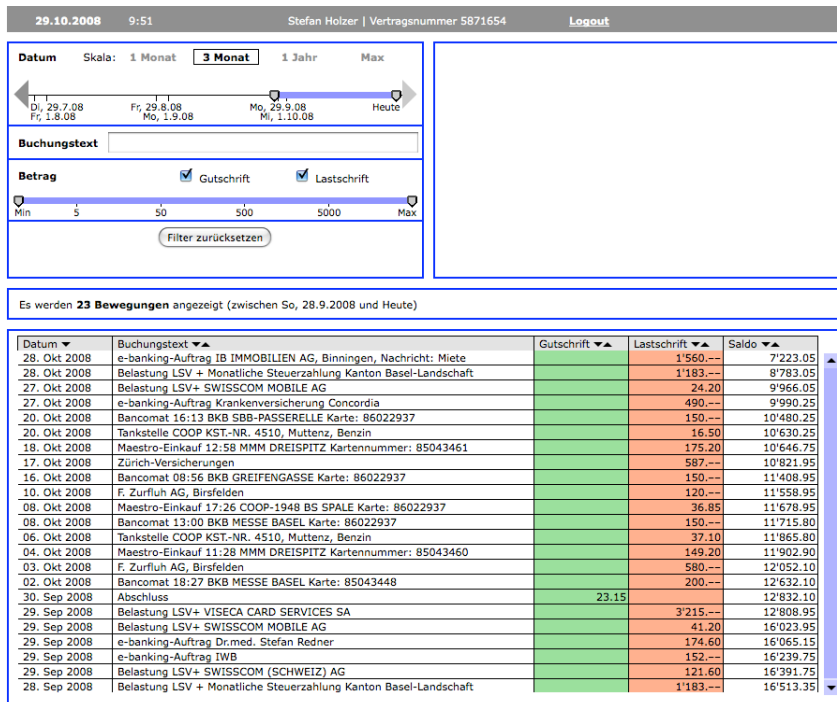


Figure 4. Condition 3: Simple Ajax, without chart.

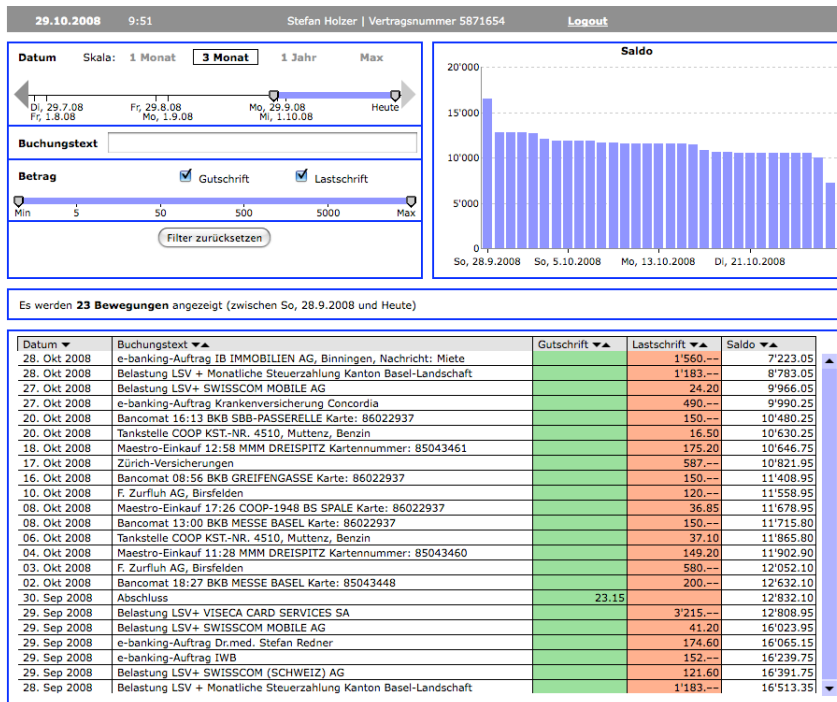


Figure 5. Condition 4: Simple Ajax, with chart.

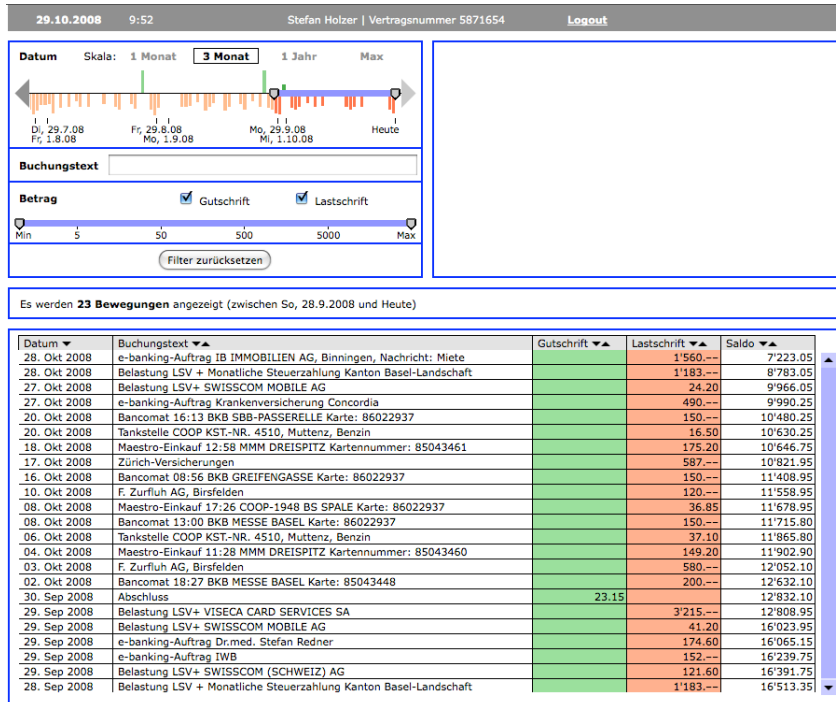


Figure 6. Condition 5: Histogram Ajax, without chart.

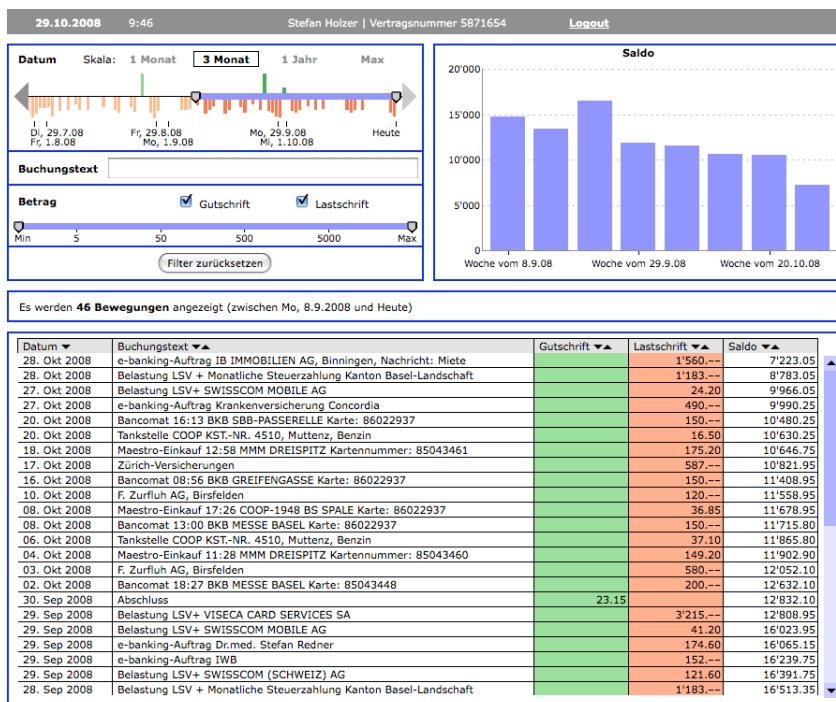


Figure 7. Condition 6: Histogram Ajax, with chart.

Procedure

The participants were tested individually in front of the eye tracking computer. After the initial calibration the experimenter left the room. Throughout the study the experimenter was sitting in the room next door and observed the participant's screen. The participant could

talk to the experimenter using a talk-back system during the entire study duration. The instructions for the general procedure appeared on the monitor and the instructions for the tasks were to be found in the study guideline. Participants received a think aloud instruction for the study and were asked to comment all steps they took to solve the tasks. The study consisted of three parts: the pre-study questionnaire, the solving of the seven different tasks on the computer and the post-study questionnaire. Participants were told that their assignment was to test the developed interface and to be critical about it.

Participants filled in the pre-study questionnaire first and were led on to solve the different tasks. The initial task was chosen in order to give the participants the possibility to familiarise themselves with the interface. The second task was designed for the interaction with different filter possibilities of the online bank separately. Task number three was included to provoke the search within the transactions texts. Task four should shed light on the usage of the chart of the account balance. Therefore data for task four will be analysed separately for some of the dependent variables. Task number five was included to have the participants use the combination of the filters for amount and text and task number six was conducted to combine the text field and date range. The last task consisted of four short subtasks in order to check on the learning effect of the previous tasks. A Summary of all tasks can be found in Appendix B. After concluding the last task participants were directly forwarded to the post-study questionnaire. Then they were forwarded to the online version of the NASA-TLX. After the debriefing participants were given their credit or payment.

## Results

We included 121 people into our analyses using SPSS 17 for Mac (SPSS inc, 2008). Data of some of the dependent variables data was missing and resulted in different sample sizes for the different dependent variables. For all conducted analyses a two-tailed alpha level of 5% was used. As recommended by Tabachnik et al. (2001) we scanned the data for group

specific univariate outliers (z-Scores  $SD > 3$ ) before starting the analysis. The distribution of the data was similar across groups on visual inspection.

60 % of all participants were experienced in online banking and used online banking in their daily live. Analyses revealed that there were no differences between participants with respect to age, gender, their experience with online banking and experience using the computer or the Internet. The answers of the question which task was the least supported in the online banking interface they currently use at home did confirm the results of the nine interviews. Most of the participants claimed searching for a specific payment as the least supported task.

### *Objective Measures*

*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. A two-way ANOVA for independent groups with chart and Ajax as the independent variables showed that the number of correctly solved task did not significantly differ between the conditions with and without the chart  $F(1, 114) = .09, p = .76$ . The chart did thus have no influence on the number of correctly solved tasks.

*Total Completion Time.* As the distribution of the task completion time differed from the normal distribution we transformed the data using a logarithmic transformation (natural). We calculated a two-way analysis of variance for unrelated samples with chart and Ajax as independent variables using the transformed data which revealed no significant differences regarding the factor chart  $F(1, 110) = 1.47, p = .23$ . The total time of solving all tasks was longest in the four Ajax conditions but there was no difference regarding the factor chart. The chart did not influence the amount of time participants needed to solve all tasks.

*Task Completion Time.* Task Completion Time was measured using manually set markers in the Tobii Studio Software at the beginning and the end of each task and was also transformed using a logarithmic transformation (natural). Condition means and standard

deviations are given in Table 2. No task showed any significant difference concerning the time for the factor chart. The participants did not differ concerning the time they needed to solve the tasks.

Table 2.

*Means and Standard Deviation of Total Completion Time and Task Completion Times per Condition in Seconds*

|                              | Total             | Task 1           | Task 2           | Task 3         | Task 4           | Task 5           | Task 6           | Task 7           |
|------------------------------|-------------------|------------------|------------------|----------------|------------------|------------------|------------------|------------------|
| Non-Ajax without chart       | 146.72<br>(45.55) | 16.61<br>(8.5)   | 21.33<br>(18.92) | 7.39<br>(2.99) | 49.5<br>(31.89)  | 18.94<br>(5.24)  | 14.89<br>(9.29)  | 18.06<br>(5.87)  |
| Non-Ajax with chart          | 136.5<br>(52.84)  | 15<br>(5.81)     | 25<br>(18.92)    | 8.67<br>(5.17) | 29.67<br>(22.06) | 21.61<br>(8.78)  | 17.44<br>(11.79) | 19.11<br>(6.72)  |
| Simple Ajax without chart    | 171.12<br>(51.5)  | 27.94<br>(16.46) | 23<br>(12.48)    | 8<br>(7.31)    | 38.82<br>(20.78) | 35.18<br>(16.63) | 18.94<br>(13.14) | 19.24<br>(4.1)   |
| Simple Ajax with chart       | 153.17<br>(44.48) | 28.44<br>(21.08) | 23.22<br>(11.87) | 8.83<br>(8.06) | 31.39<br>(22.01) | 22.61<br>(18.32) | 13.11<br>(4.92)  | 25.56<br>(10.9)  |
| Histogram Ajax without chart | 159.24<br>(50.18) | 24.76<br>(16.25) | 25.82<br>(15.91) | 6.12<br>(4.12) | 32.53<br>(19.17) | 30.41<br>(18.32) | 17.06<br>(11.68) | 22.53<br>(16.85) |
| Histogram Ajax with chart    | 122.94<br>(49.46) | 17.67<br>(9.27)  | 34.06<br>(43.71) | 5.94<br>(3.49) | 18.83<br>(12.87) | 19.11<br>(8.29)  | 12.61<br>(8.49)  | 14.72<br>(3.86)  |

Note, M= Mean, (SD= Standard Deviation)

*Clicks.* As the distribution of clicks showed a moderate positive skewness we transformed the data using a logarithmic transformation (natural). There was no significant interaction allowing the analysis of the main effect for the factor chart. The two-way ANOVA for unrelated samples with the conditions chart and Ajax as the independent variables on the transformed data revealed a significant effect for the factor chart in the total number of clicks in all tasks  $F(1,108) = 5.20, p = .03$ . Users in the chart conditions needed a significantly lower number of clicks to solve all tasks than the ones in conditions without chart. An additional analysis of task four revealed a significant effect in a two way ANOVA for unrelated samples for the factors chart  $F(1,108) = 11.23, p < .01$ . Participants in conditions including a chart needed less clicks to complete this task. Table 3 summarizes the total number of clicks and the clicks for task four. The violated assumption of homogeneity of variances led to a comparison of the conditions with and without chart within one step of the factor Ajax using a test for non-parametric data. The result of Man-Whitney U tests for task four revealed a significant difference between the conditions with and without chart in

the Non Ajax ( $U(20,19) = 114.5, p = .03$ ) and the Histogram Ajax condition ( $U(20,19) = 113.00, p = .03$ ). Participants in chart conditions needed less clicks to solve the task.

Table 3.

*Means and Standard Deviations of Click Counts per Condition per Task*

|                              | Total          | Task 4        |
|------------------------------|----------------|---------------|
| Non-Ajax without chart       | 146.72 (45.55) | 49.50 (31.89) |
| Non-Ajax with chart          | 136.50 (52.84) | 29.67 (22.06) |
| Simple Ajax without chart    | 171.12 (51.50) | 38.82 (20.78) |
| Simple Ajax with chart       | 153.17 (44.48) | 31.39 (22.01) |
| Histogram Ajax without chart | 159.24 (50.18) | 32.53 (19.17) |
| Histogram Ajax with chart    | 122.94 (49.46) | 18.83 (12.87) |

Note, M=Mean, (SD = Standard Deviation)

*Eyetracking Data.* To analyse the eye tracking data, Areas of Interest (AoI) in the Tobii Studio Software were used. For every mentioned element of the interface we created an AoI, resulting in eight different AoIs shown in Figure 8. There was an AoI for the filter box and every single element of it (date search, amount search, text search), the chart area, the summary of applied filters and the table. Additionally we placed one AoI over the whole screen. This enabled us to calculate some relational measures regarding the fixation data.

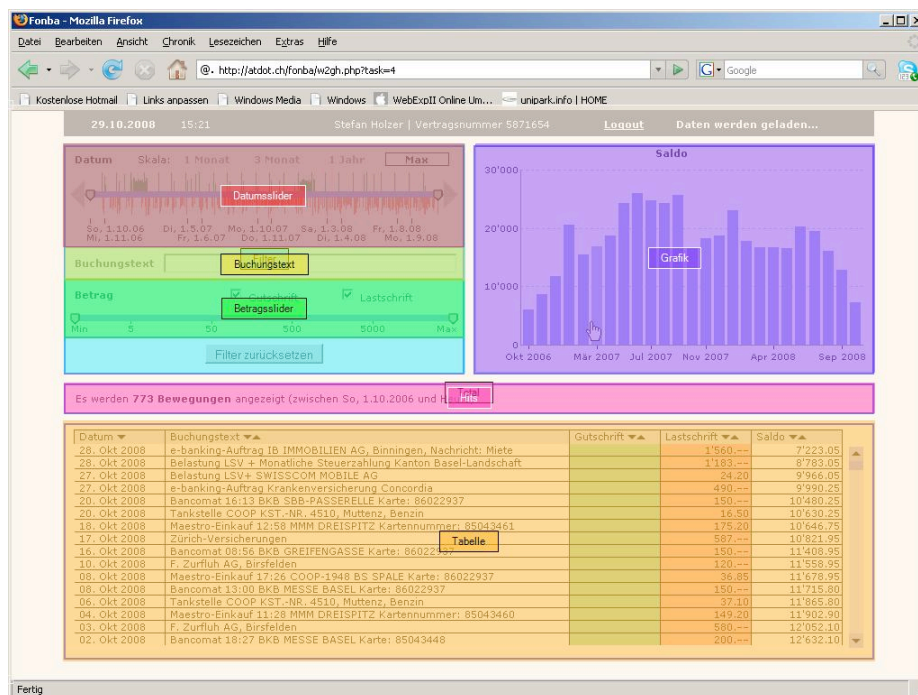


Figure 8. Areas of Interest (AoI) of all interface elements used in the analysis.

*Fixation length and number of fixations.* Analysing the data with a an ANOVA for unrelated samples with chart and Ajax as the independent variables showed no significant difference for the factor chart between all conditions neither on fixation length  $F(1,106) = 1.52, p = .22$  nor on the number of fixations for the whole screen,  $F(1,110) = 2.69, p = .10$ . A two-way ANOVA for unrelated samples with the conditions chart and Ajax as independent variables on fixation length and number of fixations of the table area however showed that there is a significant difference in the total time users spent looking on the table area  $F(1,110) = 15.42, p < .001$  and the number of fixation within the table area  $F(1,110) = 13.06, p < .001$ . Users in the conditions with a chart looked less frequently and spent less time looking at the table in order to get the solution to the tasks. Figure 9 shows the fixations lengths of the table area for all conditions.

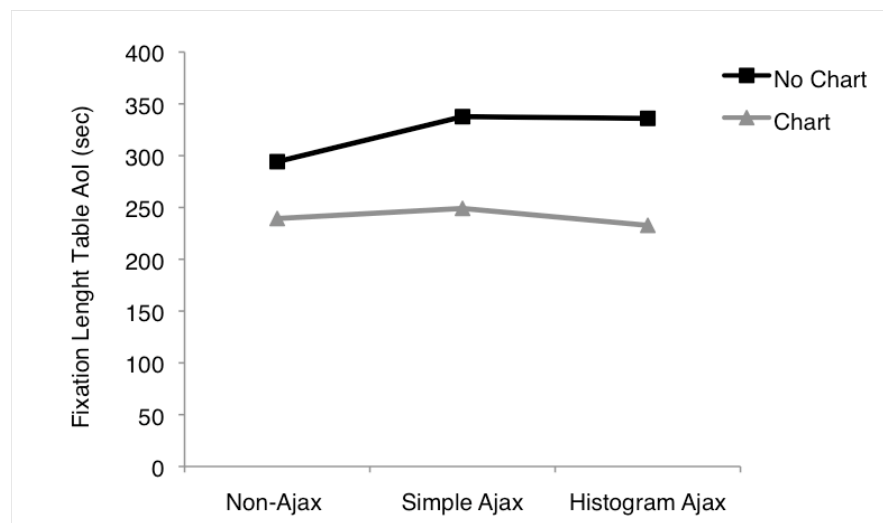


Figure 9. Fixation length of the table area showing shorter fixation lengths in conditions with chart.

Further analyses of the fixations within the chart AoI area showed that users looked at this interface element. In order to be able to calculate an effect of the usage of the chart we calculated a relational measure by putting the fixation length of the table in relation to the fixation length of the whole screen. As the fixation length of the filter box varied between conditions we wanted to suppress its influence. Therefore we calculated a corrected measure

by putting the fixation length of the table into relation to the total fixation length minus the fixation length of the filter box. The formula as follow:

$$\text{Relational Measure} = \frac{\text{Fixation length of Table Area}}{\text{Fixation length Total} - \text{Fixation length of Filter Box}}$$

A two-way ANOVA for unrelated samples with the factors chart and Ajax revealed a significant main effect of the factor chart,  $F(1,110) = 59.30, p < .001$ , for this relational measure. Figure 10 shows the relation of fixations within the table area compared to the fixations on the whole screen by condition.

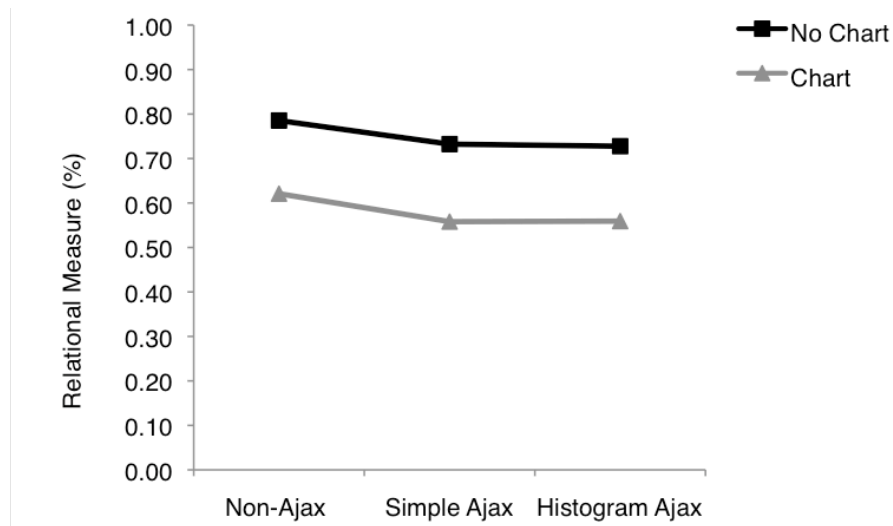


Figure 10. Relational measure for the conditions with and without chart. Calculated by the fixation length on the table area in relation to the total fixation length of the screen minus the fixation length of the filter box. Participants in the chart conditions looked at the table to a smaller extend.

Figures 11a and 11b show examples of heat maps as an example of additional qualitative analysis of the eye tracking data. These figures show the aggregated data for task four that did focus on the use of the chart. Red areas highlight areas with the largest number of fixations and follow the outline of the bars in the chart. This supports the finding that participants used the graphic in order to find the solution to task number four.



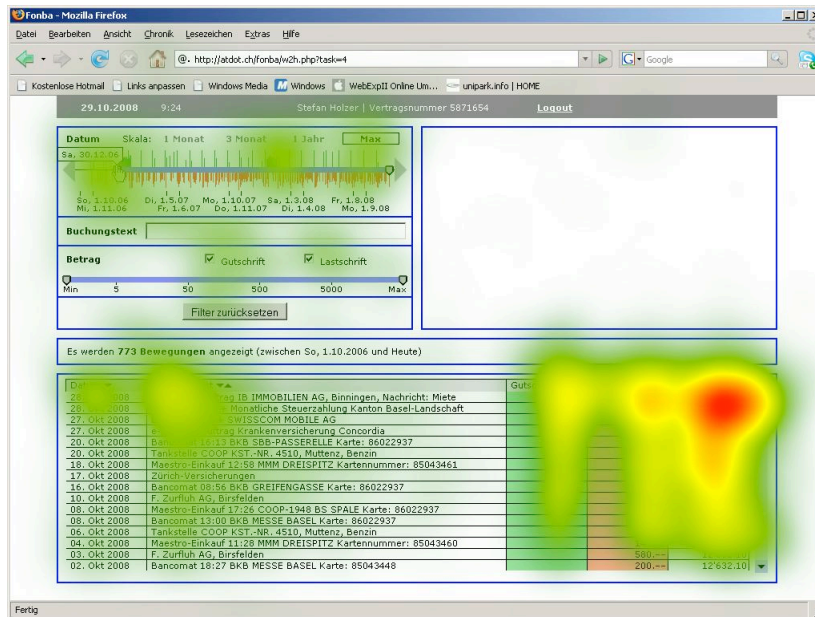


Figure 11a. Heat maps of the fixation counts aggregated over all participants in task four of condition 5, Histogram Ajax without chart.

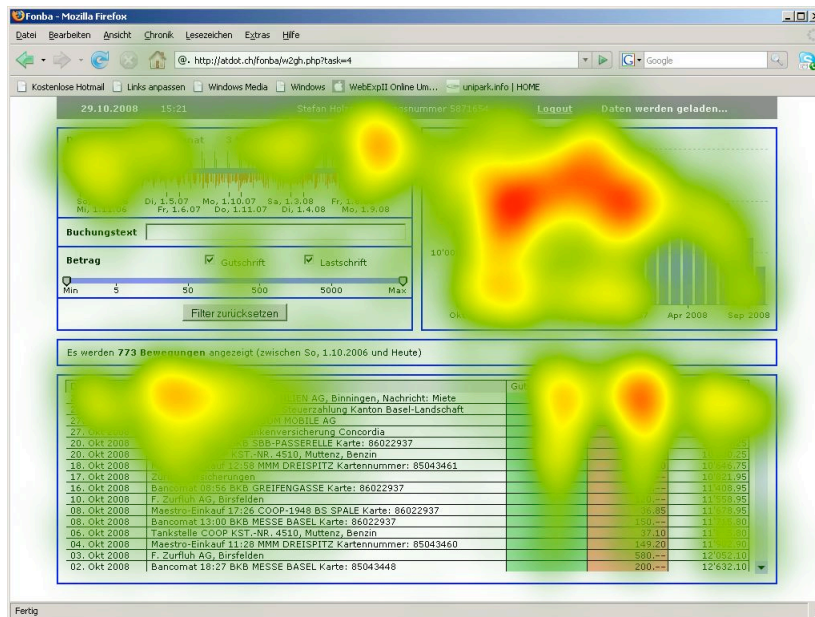


Figure 11b. Heat maps of the fixation counts aggregated over all participants in task four of condition 6, Histogram Ajax with chart.

### Logfile Analyses

*Use of the Chart.* Logfile analyses showed that the functionality for highlighting one bar in the chart was used by 29 participants (48%) and the tooltip functionality by 39 participants (65%). This indicates that the participants detected these interactive functionalities without further instruction.

*Subjective Measures*

*Ratings on 6 Point Likert Scales.* The ratings on the different scales that were analysed by using a two-way ANOVA for unrelated samples for the chart did not reveal significant differences for any of the dependent variables. Table 4 includes all subjective ratings. A level-wise comparison of the interfaces with and without chart using non-parametric tests hence revealed differences in the Histogram Ajax interface for the overall rating ( $U(20,20) = 110, p = .01$ ), organisation ( $U(20,20) = 102, p < .01$ ) and design ( $U(20,20) = 78.5, p < .001$ ). For all scales, the interface version including a chart received a superior rating.

Table 4.

*Means and Standard Deviations of Subjective Ratings*

|                              | Overall     | Comprehension | Overview    | Organisation | Design      |
|------------------------------|-------------|---------------|-------------|--------------|-------------|
| Non-Ajax without chart       | 5.16 (0.50) | 5.32 (0.83)   | 5.05 (1.08) | 5.16 (0.83)  | 3.65 (1.08) |
| Non-Ajax with chart          | 5.21 (0.88) | 5.20 (0.77)   | 5.15 (0.99) | 5.00 (0.79)  | 3.65 (1.57) |
| Simple Ajax without chart    | 4.33 (0.99) | 4.85 (0.75)   | 4.20 (1.15) | 4.20 (1.11)  | 3.15 (0.93) |
| Simple Ajax with chart       | 4.06 (1.22) | 4.63 (0.90)   | 4.11 (1.59) | 4.53 (1.35)  | 2.89 (1.41) |
| Histogram Ajax without chart | 3.75 (0.91) | 4.55 (0.89)   | 3.95 (1.32) | 3.85 (1.14)  | 2.55 (1.23) |
| Histogram Ajax with chart    | 4.58 (1.15) | 4.65 (1.14)   | 4.55 (1.19) | 4.90 (1.52)  | 4.00 (1.21) |

*Note: M=mean, (SD = Standard Deviation)*

*Rating SUS.* The ratings for the six different interfaces were all above ‘Ok’ according to the division of Bangor, Kortum and Miller (2008). The Non Ajax interfaces received scores above 80 ( $M= 81.10$  without chart,  $M=86.05$  with chart). The Simple Ajax interfaces got ratings below 70 ( $M= 67.50$  without chart,  $M=64.44$  with chart) and the Histogram Ajax without chart got a rating of 64.50 and with chart of 70.39. Analysing this data with a two-way ANOVA for unrelated samples with the factors chart and Ajax revealed no significant differences between conditions in the total score of subjective ratings ( $F(1, 114) = 0.73, p = .39$ ). Also analyses of the different subscales revealed no significant differences between the conditions with chart or without chart.

*Rating NASA-TLX.* The ratings of the six scales the cognitive load scale overall of the NASA-TLX were added to form a total score. The total score for the Simple Ajax ( $M=165$ ,  $M=166.94$ ) and Histogram Ajax ( $M=150$ ,  $M=130.26$ ) conditions were higher than for the Non Ajax versions ( $M=98.42$ ,  $M=121.32$ ). As there is no benchmark for a too high load we could not compare the measured load in our study to other interfaces (Hart, 2007). The total scores were analysed using a two-way ANOVA for unrelated samples with the factors chart and Ajax. There was no significant difference regarding the factor chart  $F(1, 111) = .04$ ,  $p = .85$ . The rating of the subjectively experienced cognitive load did not significantly differ between the conditions whether there was a chart included or not. Descriptive data reveals that for the Non Ajax and the Simple Ajax conditions the chart resulted in a higher load, whereas for the Histogram Ajax the chart caused a lower rating.

*Use of the Bank.* Regarding the question whether participants would use this interface there was no significant difference between the conditions for the factor chart using chi-square  $\chi^2(1, N = 121) = 0.22$ ,  $p = .64$ . The participants did not differ in their choice depending on whether the interface included a chart or not.

*Open Questions.* The answers to the open questions concerning the pro and cons for using this interface were put into different categories. Overall there were more positive statements than negative ones, which suggest that the interface was accepted by most of the participants. In the positive statements the screen organisation and the handling was most referred to while in the negative statements comments concerning the date selection and the design prevailed. The mainly positive comments about the composition and the handling of the interface indicate that the participants approved of the layout of the interface. The large proportion of negative statements concerning the date input comes from the Simple and the Histogram Ajax conditions. The negative comments regarding the design of the interface were distributed evenly over all conditions. In Figure 12, a summary of all comments divided into fourteen categories can be found.

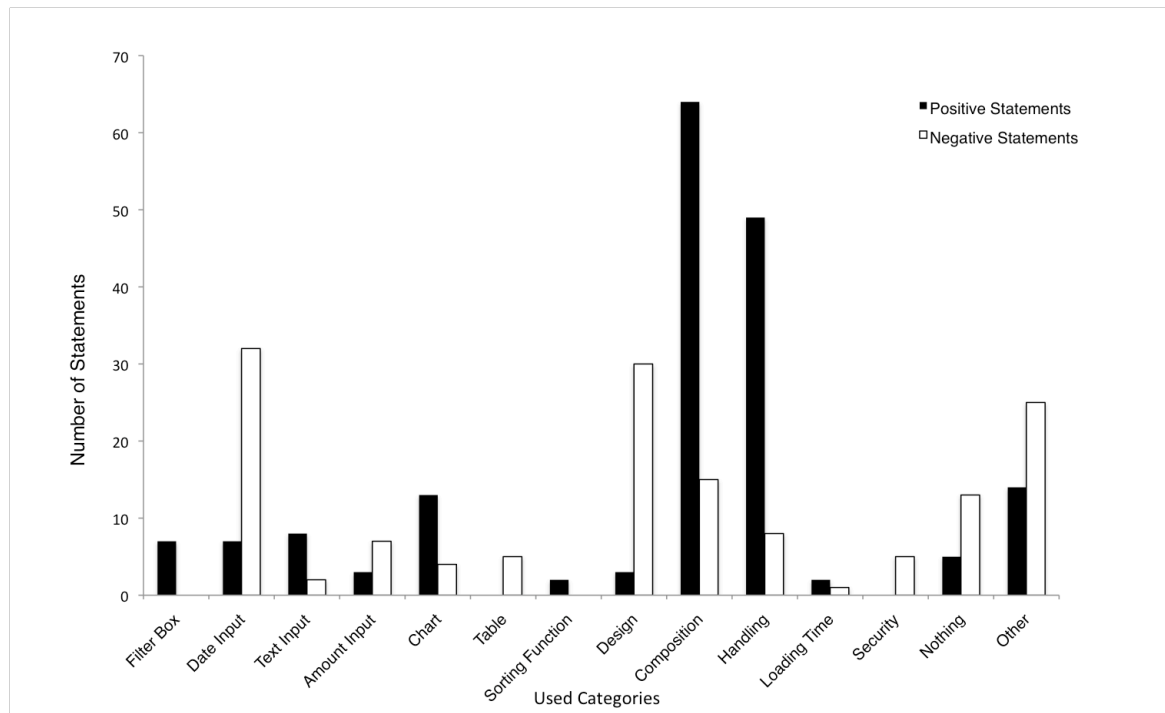


Figure 12. Numbers of positive and negative statements divided into fourteen categories.

## Discussion

One aim of this study was to evaluate whether the use of a chart could be beneficial to the interface of an online banking account. To test this we set up a study including the two factors Ajax and chart. The introduction of an illustration of the account's balance in terms of an interactive chart has not been tested so far and therefore it was an explorative study.

In general, all participants could handle the tasks. This can be underlined with the large number of correctly solved tasks throughout all conditions. From the answers to the open questions it can be inferred that people liked the configuration of all the elements on one screen. Concerning the handling and the layout of the interface there were much more positive responses than negative ones. We interpret these results to the effect that the interface including the innovative arrangement of the information found general approval by the majority of the participants.

Analysing the objective data did reveal inconsistent results. Contrary to our first hypothesis task completion time for each task and the overall completion time showed no

significant difference. The chart did hence not influence the time to solve all tasks in a positive way. Also the analysis of every single task did not yield any differences. This means that the integration of the chart did not have any influences on the time participants needed to solve the tasks whether it was a task designed to test the use of the chart or not. This is in accordance to findings of Tudoreanu and Kraemer (2008) who found no difference in the average time required to solve a task between a text only and a chart and text condition.

The results of other objective data however support the hypothesis that if there is a chart or graphical element at hand users do actually make use of it to solve the posed questions. The overall count of mouse clicks was significantly lower when the chart was included in the interface. This finding was constant for the Non Ajax, the Simple and the Histogram Ajax interface. As clicks were needed to scroll through the table where the search results are displayed, a reduced number of clicks indicate that the participants could reduce the search within the table. The analyses of the eye tracking data further support these findings. Research has provided evidence that people look at what they are focussing and are mentally working on and that their eyes do not move around at random (Sibert and Jacob, 2000). The data of our study shows that participants spent less time searching the table area and used the chart instead to get the solution for the task. This finding can be interpreted in terms that the information within the chart was judged as equivalent to the information within the tabular representation of the account balance. Extracting data from a tabular form seems to be more exhausting as it needs scrolling; additional mouse clicks and requires additional time. The fewer users have to interact with the scrolling bar, the less effort they have to put into the task.

As the analysis revealed, participants detected the interactive possibility of the chart without explicit instruction. The majority of the participants did experiment with the interactivity at some point throughout the study, indicating that they either already had experience with interactive bar charts or are generally expecting charts to be interactive in

some kind. Nevertheless, they only discovered some of the possible features of the chart. According to Rasch et al. (2009) the visualisation format affects the way of interaction with the animation and the affordance of the chart could have been too small.

The cognitive load as a measure of the impact on working memory did not show any differences between the conditions with and without chart. As ratings did not differ for the different conditions it could be argued that the chart did neither have a positive (in terms of lowering) or a negative (in terms of heightening the amount of load participants did experience) influence. The results are different for every subscale and for every level of the factor Ajax. Concerning the total score, the Histogram Ajax with chart condition is the only one showing a lower cognitive load. An explanation for these incoherent findings could be that this study measured cognitive load by subjective ratings on different scales whereas other studies used the dual-task paradigm (Chandler & al., 1991).

For all subjective ratings no differences between the conditions with and without chart could be found. A possible explanation is the generally low rating or general low variance in ratings. As there were marginally significant results in terms of the design rating it can be hypothesised that the additional graphical feature had a positive effect on the overall impression of the interface. However, another important implication can be derived from the general low rating of the design. The decision to use only a very simplified and plain prototype was not appreciated by the participants. Analysing the comments of the open text fields supports this. Although the experimenter told the participants that they were testing a first prototype the participants possibly transferred their impression from the interface's layout to the security for example. This could also have negatively affected the overall ratings and the ones on the SUS scale. Tractinsky, Katz and Ikar (2000) could show that humans prefer websites that are aesthetically well designed and that the attractiveness of a website affects the user's evaluation of it.

### *Limitations*

Since we wanted to have tasks and settings simulating tasks usually executed in an online banking interface, we included combinatory tasks instead of testing each element separately. Consequently the influence of each interface element such as the chart on the overall performance can only roughly be estimated. Additional questions concerning the chart and the participants' general attitude towards usage and application of charts and other graphical representations should have been integrated into the post-study questionnaire.

The analysis of the open questions suggested that the participants' attitude concerning the security should have been queried. The attitude towards online banking in general and worries concerning the security of online banking might have influenced participants' ratings. People who reject online banking or who are worried about the security of online banking could have given the interface a lower rating.

Although originally intended, we did not include questions querying the desirability of the interface and the 'joy of use'. Joy of use characterizes the positive subjective experience when using a tool or website (Hatcher, 2001). A further study should include questions concerning this area to test for effects such as that although the tool is not as easy to use and needs support it will be rated better just because it is more enjoyable.

### *Further Suggestion for Research*

To achieve clearer results further research is needed. Within this study design it was only possible to extract the contribution of the chart to a certain extent. There would be more tasks needed where participants have to interact with the chart to be able to conclude the specific influence of the chart. One suggestion for further research would be to investigate on the interactivity of a chart. Some participants assumed that the chart was strongly connected to the settings in the filter box. They expected that if they only selected to see the debits or credits respectively they would be only presented the chosen type of transaction in the chart. Chandler (2009) states, that the form of instructional animations influences its success. The

same might hold for this chart. Shah et al (2005) showed that also the type of graph influences the users' comprehension of the communicated information. The characteristics of the chart should be examined and in a redesign, the characteristics should be stronger based on cognitive principles of perception. In accordance with Chandler (2009) research should further focus on how people perceive and interpret the information presented in charts and graphs and not only on how to adapt new technological functionalities.

The participants' comments and the experimenters' observations suggest that some participants would rather have the chart being displayed on request. They emphasised that they liked the feature but it would be sufficient for them to have a chart available if they have to solve tasks involving some kind of comparison. To investigate this, achievement in comparison tasks with more practical relevance to daily life, such as comparing the balance of two dates, would have to be tested.

### *Conclusion*

This study could show that participants did generally speaking accept the new layout of the online banking interface where input and output were included on one screen. The analysis of objective and subjective data concerning the use of an interactive chart to display the account balance show that participants did not need more time for single tasks or to complete the whole study. Neither did they rate the interface differently on the subjective scales or estimate the experienced cognitive load differently. The interface with chart did not influence the time to solve the posed tasks, was not more negatively rated but reduced the number of clicks used for a specific comparison task and the eye tracking data supports that the exhausting search within the output table can be reduced. Further research is needed, but the concept of presenting the account data as a chart could come to define a new standard in an online banking interface.



## References

- Ahlberg, C., Williamson, C., & Shneiderman, B. (1992). Dynamic queries for information exploration: An implementation and evaluation. *CHI '92: Proceedings of the SIGCHI conference on human factors in computing systems*, 619–626.
- Ainsworth, S. (1999). The functions of multiple representations. *Computers & Education*, 23, 131–152.
- Amrhein, P. C, MacDaniel, M. A., & Waddill, P. (2002). Revisiting the picture-superiority effect in symbolic comparisons: Do pictures provide privileged access? *Journal of experimental psychology. Learning, memory, and cognition*, 28, 843–857.
- Ayres, P., & Paas, F. (2007). Making instructional animations more effective: A cognitive load approach. *Applied Cognitive Psychology*, 21, 695–700.
- Basler Kantonalbank, Demobank (n.d.) [WWW Document]. Retrieved September 4, 2008 from <https://banking.bkb.ch/secure/welcome.jspa>
- Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. *International Journal of Human-Computer Interaction*, 24, 574–594.
- Bodemer, D., Ploetzner, R., Bruchmüller, K., & Häcker, S. (2005). Supporting learning with interactive multimedia through active integration of representations. *Instructional Science*, 33, 73–95.
- Brooke, J. (1996). SUS: A “quick and dirty” usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdemeester & I. I. McClland (Eds.), *Usability evaluation in industry* (pp. 189–194). London: Taylor & Francis.
- Brotherstone, H., Miles, A., Robb, K. A., Atkin, W., & Wardle, J. (2006). The impact of illustrations on public understanding of the aim of cancer screening. *Patient Education and Counseling*, 63, 328–335.
- Card, S. K., Mackinlay, J. D., & Shneiderman, B. (Eds.) (1999). *Readings in Information Visualization: Using Vision to Think*. San Francisco, CA: Morgan Kaufmann Publishers.

- Chandler, P. (2009). Dynamic visualisations and hypermedia: Beyond the "Wow" factor. *Computers in Human Behaviour*, 25, 389–392.
- Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, 8, 293–332.
- Credit Suisse Demobank (n.d.) [WWW Document]. Retrieved September 6, 2008 from <http://www.directnet.com/demo/dn/de/index.html>
- Credit Suisse (2007). Retrieved March 6, 2009 from <http://emagazine.credit-suisse.com/app/article/index.cfm?fuseaction=OpenArticle&aoid=186809&lang=DE>
- Danserau, D. F., & Simpson, D. D. (2009). A picture is worth a thousand words: The case for graphic representations. *Professional Psychology: Research and Practice*, 40, 104–110.
- Eilam, B., & Poyas, Y., (2008). Learning with multiple representations: Extending multimedia learning beyond the lab. *Learning and Instruction*, 18, 368–378.
- Fin.Kom Magazin für Financial 2/07 (2007). Retrieved February 22, 2009 from [http://cms.ultrabold2.com/fileadmin/user\\_upload/referenzen/PDFs/FinKom\\_Bsp\\_3.pdf](http://cms.ultrabold2.com/fileadmin/user_upload/referenzen/PDFs/FinKom_Bsp_3.pdf)
- Garett, J. J. (2005). Ajax: A new approach to web applications. Retrieved March 5, 2009 from <http://adaptivepath.com/ideas/essays/archives/000385.php>
- Gershon, N., & Page, W. (2001). What storytelling can do for information visualization. *Communications of the ACM*, 44, 31–37.
- Google.com, (n.d) [WWW Document]. Retrieved April 10, 2009 from <http://www.google.com>
- Hart, S. (2007). Nasa-Task load index (Nasa-TLX); 20 years later. *Proceedings of the Human Factors and Ergonomics Society 50th annual Meeting* (pp. 904-908). Santa Monica, CA: Human Factors & Ergonomics Society.
- Hart, S. G., & Staveland, L. (1988). Development of NASA-TLX (task load index). Results of empirical and theoretical research. In: P. A. Hancock & N. Meshkati (Eds.), *Human Mental Workload* (pp. 239–250). Amsterdam: Elsevier Science.

- Hatcher, M. (2001). Joy of use – Determinanten der Freude bei der Software-Nutzung. In: H. Oberquelle, R. Oppermann & J. Krause (Eds.), *Mensch & Computer 2001* (pp. 445–446). Stuttgart: B. G. Teubner.
- Heise Online Dienst (2009). Retrieved March 4, 2009 from <http://www.heise.de/newsticker/Online-Banking-waechst-nur-langsam--/meldung/133331>
- Hornbaek, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. *International Journal Human-Computer Studies* 64, 79–102.
- Hughes, T. (2003), Marketing challenges in e-banking: Standalone or integrated? *Journal of Marketing Management*, 19, 1067–1085.
- InfoVis.org, (n.d.) [WWW Document]. Retrieved February 20, 2009 from <http://www.infovis.org/>
- ISO, (1998). *Ergonomic requirements for office work with visual display terminals (VDTs) part 11: guidance on usability*. International Standards Organization, Geneva, Switzerland.
- Khan, M. S., Mahapatra, S. S., & Sreekumar (2009). Service quality evaluation in Internet banking: An empirical study in India. *International Journal of Indian Culture and Business Management*, 2, 30–46.
- Mayer, R., & Moreno, R. (2002). Aids to computer-based multimedia learning. *Learning and Instruction*, 12, 107–119.
- Miller, H. (2005). Information quality and market share in electronic commerce. *Journal of Services Marketing*, 19, 93–102.
- O'Reilly, T. (2005). *What is Web 2.0, Design patterns and business models for the next generation of software*. [WWW Dokument]. Retrieved December 17, 2006 from <http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html>
- Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt, Rinehart & Winston.

- Paulson, L. (2005). Building rich web applications with ajax. *Computer*, 38, 14–17.
- Postfinance Demobank, (n.d.) [WWW Document]. Retrieved September 4, 2008 from [https://e-finance.postfinance.ch/ef/public/cc/demo/d\\_yellownet\\_d.htm](https://e-finance.postfinance.ch/ef/public/cc/demo/d_yellownet_d.htm)
- Ritzmann, L. (2009). *Using Autosuggest and Dynamic Querying to Enhance the Usability of Online Banking Interfaces*. Unpublished master's thesis, University of Basel, Switzerland.
- Pretorius, M. C., Calitz, A. P. C., & Van Greunen, D. (2005). The added value of eye tracking in the usability evaluation of a network management tool. *Proceedings of SAICSIT 2005*, 1–10.
- Rasch, T., & Schnotz, W. (2009). Interactive and non-interactive pictures in multimedia learning environments: Effects on learning outcomes and learning efficiency. *Learning and Instruction* (work in press), 1–12.
- Schmutz, P., Tuch, A., & Opwis, K. (2008). NASA-TLX webbased version. [web application]. URL <http://www.psycho.unibas.ch/NASATLX>.
- Shah P., Freedman, E. C., & Vekiri, I. (2005). The comprehension of quantitative information in graphical displays. In: P. Shah & A. Miyake (Eds.), *The Cambridge handbook of visuospatial thinking* (pp. 426–476). Cambridge: Cambridge University Press.
- Sibert, L. E., & Jacob, R. J. K. (2000). Evaluation of eye gaze interaction. In: *Proceedings of CHI 2000: Human Factors in Computing Systems* (pp. 281–288). The Hague, The Netherlands: ACM Press.
- Skorge, P. (2005). Visual representations as effective instructional media in foreign language. *Poznan Studies in Contemporary Linguistics*, 44, 265-281.
- SPSS for Mac, (2008) [Computer software]. *Statistical Package for the Social Sciences*. Released 17.0.1 2008. Chicago: SPSS Inc.
- Stimmt AG, (n.d) [WWW Dokument]. Retrieved March 7, 2009 from <http://www.stimmt.ch>

- Sweller, J., van Merriënboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10*, 251–296.
- Tabachnick, B. G., & Fidell, L. S. (2001). Cleaning up your act. Screening data prior to analysis. In B. G. Tabachnick & L. S. Fidell (Eds.), *Using Multivariate Statistics* (pp. 56–110). 4th edition. Boston: Allyn and Bacon.
- Tan, M., & Teo, T. S. H. (2000). Factors influencing the adoption of Internet banking, *Journal of the Association for Information Systems*, *1*, 1–42.
- Traktinsky, N., Katz, A. S., & Ikar, D. (2000). What is beautiful is usable. *Interacting with Computers*, *13*, 127–145.
- Tudoreanu, M. E., & Kraemer, E. (2008). Balanced cognitive load significantly improves the effectiveness of algorithm animation as a problem-solving tool. *Journal of Visual Languages and Computing*, *19*, 598–616.
- Tufte, E. R. (1997). *Visual Explanations: Images and Quantities, Evidence and Narrative*. Cheshire, CT: Graphics Press.
- Tversky, B. & Bauer Morrison, J. (2002). Animations – can it facilitate. *International Journal of Human-Computer Studies*, *57*, 247–262.
- Weir, C. S., Anderson, J. A., & Jack, M. A. (2006). On the role of metaphor and language in design of third party payments in ebanking: Usability and quality. *International Journal of Human-Computer Studies*, *64*, 771–785.
- Weir, C. S., McKay, I., & Jack M. A. (2007). Functionality and usability in design for estatements in ebanking services. *Interacting with Computers*, *19*, 241–256.
- Weir, C. S., Douglas, G., Carruthers, M., & Jack, M. (2009). User perceptions of security, convenience and usability for ebanking authentication tokens. *Computers & Security*, *28*, 47–62.
- Zürcher Kantonalbank Demobank, (n.d.) [WWW Document]. Retrieved September 17, 2008 from <http://www.zkb.ch/demohtml/gesamtuebersicht/gesamtuebersicht.htm>

Zeix.com (2003, October). [WWW Document]. Retrieved March 4, 2009 from

<http://www.zeix.com/aktuelles-publikationen/2003/10/10/%C2%ABwir-machen-jetzt-onlinebanking%C2%BB/>

## Appendix A

### Pre Test Questionnaire

Im Folgenden werden wir Ihnen einige kurze Fragen zu Ihrer Person, sowie Ihrem Online Banking Verhalten stellen.

Ihre Versuchsperson Nr.:

Ihr Geschlecht: männlich  weiblich

Ihr Alter:

Ihr Beruf:

Studieren Sie? Ja  Nein

Falls Sie studieren, welche Studienrichtung?

Falls Sie studieren, in welchem Semester?

Schätzen Sie Ihre Erfahrung in folgenden Bereichen ein:

Bedienen von Computern: Kein Wissen     Experte

Surfen im Internet: Kein Wissen     Experte

Buchen / Einkaufen im Internet: Kein Wissen     Experte

Verwendung von E-Mails: Kein Wissen     Experte

Online Banking: Kein Wissen     Experte

Wie häufig sind Sie im Internet?  Mehrmals pro Monat  
 1 x pro Woche  
 Mehrmals pro Woche  
 Täglich

Für wen handhaben Sie die Finanzen? (Mehrfachnennungen möglich)  
 Für mich selbst  
 Für meine Familie  
 Für meine Firma  
 Für meinen Verein  
 Andere  
 Ich verwalte meine Finanzen nicht selber

Verwenden Sie Online Banking?  Ja  
 Nein

Wie nutzen Sie Online Banking?  
 Für mich selber  
 Für meine Familie  
 Für meine Firma  
 Für meinen Verein  
 Andere  
 Verwende kein Online Banking

## Visualisation of the Account Balance with a Bar Chart

- Bei welcher Bank haben Sie ein Online Banking Konto?  
(Mehrfachnennungen möglich)**
- UBS
  - Credit Suisse
  - Post Finance
  - Raiffeisen
  - BS Kantonalbank
  - Andere Kantonalbank
  - Migros Bank
  - Bank Coop
  - Andere Bank
  - Verwende kein Online Banking

- Wie oft loggen Sie sich ein?**
- Seltener als 1 x pro Monat
  - Einmal pro Monat
  - Mehrmals pro Monat
  - 1 x pro Woche
  - Mehrmals pro Woche
  - Täglich
  - Mehrmals pro Tag
  - Verwende kein Online Banking

- Für welche Aufgaben nutzen Sie Online Banking?**
- Zahlungen tätigen
  - Zahlung suchen / kontrollieren
  - Kontoübersicht
  - Börsenaufträge
  - Andere
  - Verwende kein Online Banking

- Welche Aufgabe erledigen Sie am häufigsten über Online Banking?**
- Zahlungen tätigen
  - Zahlung suchen / kontrollieren
  - Kontoübersicht
  - Börsenaufträge
  - Andere
  - Verwende kein Online Banking

- Für welche Aufgabe benötigen Sie gefühlsmässig am meisten Zeit pro Login?**
- Zahlungen tätigen
  - Zahlung suchen / kontrollieren
  - Kontoübersicht
  - Börsenaufträge
  - Andere
  - Verwende kein Online Banking

- Welche der folgenden Aufgaben kann über Ihren Online Banking Account am schlechtesten gelöst werden?**
- Zahlungen tätigen
  - Zahlung suchen / kontrollieren
  - Kontoübersicht
  - Börsenaufträge
  - Andere
  - Verwende kein Online Banking

## Post Test Questionnaire

Bitte beantworten Sie folgende Fragen und vergeben Sie Noten entsprechend dem Schweizer Schulnotensystem.

- 1 = sehr schlecht  
2 = schlecht  
3 = ungenügend  
4 = genügend  
5 = gut  
6 = sehr gut

|   |                            |                            |                            |                            |                            |                            |  |
|---|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|--|
| Wie beurteilen Sie diese Online Bank im Allgemeinen?              | 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> | 6<br><input type="radio"/> | keine Antwort<br><input type="radio"/> |
| Wie beurteilen Sie die Verständlichkeit der verwendeten Begriffe? | 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> | 6<br><input type="radio"/> | keine Antwort<br><input type="radio"/> |
| Wie beurteilen Sie die Übersichtlichkeit dieser Online Bank?      | 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> | 6<br><input type="radio"/> | keine Antwort<br><input type="radio"/> |
| Wie beurteilen Sie die Organisation dieser Online Bank?           | 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> | 6<br><input type="radio"/> | keine Antwort<br><input type="radio"/> |
| Wie beurteilen Sie das Design dieser Online Bank?                 | 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> | 6<br><input type="radio"/> | keine Antwort<br><input type="radio"/> |



## Visualisation of the Account Balance with a Bar Chart

|  |                           |                       |                       |                       |                       |                      |               |
|--|---------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------|---------------|
| Gerne würde ich diese Online Bank öfter verwenden.   | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Ich empfand diese Online Bank als unnötig kompliziert.   | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Diese Online Bank empfand ich als einfach bedienbar.   | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Wahrscheinlich würde ich die Unterstützung eines Technikspezialisten benötigen, falls ich diese Online Bank benützen wollte. | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Ich finde, dass die verschiedenen Funktionen der Online Bank gut integriert sind.  | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Der Aufbau dieser Online Bank ist nicht konsistent.  | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Ich kann mir vorstellen, dass die meisten Leute den Umgang mit dieser Online Bank schnell beherrschen werden.                | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Es war mühsam, diese Online Bank zu verwenden.   | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Ich fühlte mich sicher im Umgang mit der Online Bank.  | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Um die Online Bank benützen zu können, müsste ich viele Dinge lernen.  | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |
| Ich empfand die Funktionen dieser Online Bank als nützlich.  | Stimme überhaupt nicht zu | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Stimme vollkommen zu | Keine Antwort |

|  |        |           |       |
|--|--------|-----------|-------|
| Willkommen   | Teil 1 | Teil 2    | Danke |
| <hr/>  |        |           |       |
| <b>Wie sehr haben Sie die Aufgaben mental in Anspruch genommen (denken, entscheiden, erinnern etc.)?</b> <a href="#">?</a>     |        |           |       |
| <input type="range"/>  |        |           |       |
| sehr niedrig   |        | sehr hoch |       |
| <hr/>  |        |           |       |
| <b>Wie sehr haben Sie die Aufgaben körperlich in Anspruch genommen (klicken, scrollen, Bewegungen etc.)?</b> <a href="#">?</a> |        |           |       |
| <input type="range"/>  |        |           |       |
| sehr niedrig   |        | sehr hoch |       |
| <hr/>  |        |           |       |
| <b>Wie sehr fühlten Sie sich unter Zeitdruck?</b> <a href="#">?</a>  |        |           |       |
| <input type="range"/>  |        |           |       |
| sehr niedrig   |        | sehr hoch |       |
| <hr/>  |        |           |       |
| <b>Wie gut denken Sie, haben Sie die Aufgabe lösen können?</b> <a href="#">?</a>   |        |           |       |
| <input type="range"/>  |        |           |       |
| sehr schlecht  |        | sehr gut  |       |
| <hr/>  |        |           |       |
| <b>Wie anstrengend war für Sie das Lösen der Aufgaben?</b> <a href="#">?</a>   |        |           |       |
| <input type="range"/>  |        |           |       |
| sehr niedrig   |        | sehr hoch |       |
| <hr/>  |        |           |       |
| <b>Wie sehr hat Sie das Lösen der Aufgabe frustriert?</b> <a href="#">?</a>  |        |           |       |
| <input type="range"/>  |        |           |       |
| sehr niedrig   |        | sehr hoch |       |
| <input type="button" value="weiter"/>  |        |           |       |

## Appendix B

Stellen Sie sich vor, Sie seien Stefan, ein sympathischer Mitdreissiger. Er ist Vater von zwei Kindern und leitet in seiner Freizeit den Basketball Club Möhlin (BCM). Stefan verwendet für seine Finanzen, sowohl privat als auch für seinen Verein, seit mehreren Jahren Online Banking.

Während dieser Studie werden Ihnen verschiedene Aufgaben präsentiert, welche Sie in der Rolle von Stefan auf seinem Online Bank Account lösen sollen.

Die Aufgaben werden Ihnen auf den folgenden Seiten dieses Leitfadens präsentiert. Bei einigen der Aufgaben werden Sie Lösungen aufschreiben müssen. Diese können Sie direkt in diesen Leitfaden schreiben.

Aus Gründen der Vergleichbarkeit gilt für alle Aufgaben der 29.10.2008 als heutiges Datum.

Wichtig: Bei sämtlichen Aufgaben werden nicht Sie oder Ihre persönliche Leistung getestet, sondern die Benutzerfreundlichkeit des Online Bank Accounts.

Wenn Sie keine Fragen mehr haben, folgen Sie bitte den Instruktionen auf dem Bildschirm. Ansonsten rufen Sie die/den ExperimentleiterIn.

### Aufgaben:

**1a)** Sie möchten sich alle Buchungen zwischen dem 1.8.08 und dem 30.9.08 ansehen. Wählen Sie das Datum so, dass alle Buchungen, die in diesem Zeitraum getätigt wurden, in der Tabelle dargestellt werden.

**1b)** Sie interessieren sich nur für die grösseren Beträge. Deshalb möchten Sie sich nur die Buchungen mit einem Betrag von *ungefähr* 300.– (oder mehr) ansehen. Wie viele Buchungen gibt es in diesem Zeitraum mit einem Betrag von über 300.–?  
Anzahl Buchungen: \_\_\_\_\_

**1c)** Lassen Sie sich nur die Lastschriften darstellen, um diese für eine spätere Verarbeitung (nicht Teil dieser Studie) zu kopieren.

**2)** Sie erledigen Ihre Wocheneinkäufe wöchentlich im MMM Dreispitz. Für die Budgetplanung '09 möchten Sie sich einen Überblick verschaffen über diese Einkäufe.

**2a)** Betrachten Sie die maximale Zeitspanne (1.10.06 – 28.10.08), die Ihnen in der Online Bank zur Verfügung steht. Lassen Sie sich in der Tabelle alle Buchungen im MMM Dreispitz dieses Zeitraumes darstellen.

**2b)** Wann fand der teuerste Einkauf im MMM Dreispitz statt und wie viel Geld haben Sie dafür ausgegeben?  
Wann fand der günstigste Einkauf im MMM Dreispitz statt und wie viel Geld haben Sie dafür ausgegeben?

Datum des teuersten Einkaufs: \_\_\_\_\_  
Preis des teuersten Einkaufs: \_\_\_\_\_  
Datum des günstigsten Einkaufs: \_\_\_\_\_  
Preis des günstigsten Einkaufs: \_\_\_\_\_

**3)** Sie wollen herausfinden, wie hoch die LSV Belastung der Swisscom Mobile im letzten Monat war. Sie wissen, dass das Abrechnungsdatum immer nach dem 25. des Monats ist. Wie hoch war die Belastung Ende September 08?  
Belastung: \_\_\_\_\_

4) Für Ihre Budgetplanung möchten Sie einen Überblick erhalten über den gesamten Saldoverlauf der letzten 2 Jahre (1.10.06 – 28.10.08).

4a) Bitte beschreiben Sie den Verlauf des Saldos mit eigenen Worten.  
Saldoverlauf (in Stichworten):

4b) Auf welche Buchungen können Sie allfällige grössere Sprünge im Saldo zurückführen?  
Bitte notieren Sie den Buchungstext und den Betrag.

Buchungstext: \_\_\_\_\_ Betrag: \_\_\_\_\_  
Buchungstext: \_\_\_\_\_ Betrag: \_\_\_\_\_

5) Sie möchten herausfinden, wie viele Mitglieder des Basketball Clubs Möhlin (BCM) ihren Mitgliederbeitrag für das Jahr 08 bezahlt haben.  
Die Mitglieder hatten während dem Januar 08 Zeit, den Betrag einzuzahlen.  
Auf ihrem Einzahlungsschein sollten sie sowohl ihren Vor- und Nachnamen, als auch den Vermerk BCM eintragen.

Es gibt im Verein folgende Mitgliedschaften:

Aktiv: 140.-  
Junior: 70.-  
Passiv: 40.-

Beispiel einer Buchung:

29. Jan 2007 |Gutschrift Mitgliederbeitrag BCM Dominik Wagner |140.- | 19'921.65

5a) Wie viele Mitglieder haben einen Mitgliederbeitrag einbezahlt?

Anzahl Mitglieder: \_\_\_\_\_

5b) Wie viele Mitglieder haben einen Passivbeitrag einbezahlt?

Anzahl Passivbeiträge: \_\_\_\_\_

5c) Wie viele Mitglieder haben einen Aktivbeitrag einbezahlt?

Anzahl Aktivbeiträge: \_\_\_\_\_

6) Mit Ihrer Familie verbringen Sie die Sportferien seit 2 Jahren im Chalet Matterhornblick in Fiesch. Sie möchten nun wissen, ob Sie im Januar 07 gleich viel für die Chaletmiete bezahlt hatte wie im Januar 08.

Wie viel haben Sie im Januar 07 für das Ferienhaus ausgegeben? \_\_\_\_\_

Wie viel haben Sie im Januar 08 für das Ferienhaus ausgegeben? \_\_\_\_\_

7) Abschliessend möchten wir Ihnen noch folgende Kurzaufgaben stellen.

7a) Notieren Sie bitte die Anzahl Buchungen zwischen dem 1.03.08 und dem 31.03.08.

Anzahl Buchungen: \_\_\_\_\_

7b) Notieren Sie bitte die Anzahl Buchungen, die das Wort „Coop“ beinhalten und zwischen 28.09.08 und 29.10.08 stattgefunden haben. Dieser Zeitraum ist bereits eingestellt, wenn Sie die Filter zurückgesetzt haben.

Anzahl Buchungen: \_\_\_\_\_

7c) Notieren Sie bitte die Anzahl Buchungen, die einen Betrag von *ungefähr* 2000.- oder mehr haben und die zwischen dem 28.09.08 und 29.10.08 stattgefunden haben. Dieser Zeitraum ist bereits eingestellt, wenn Sie die Filter zurückgesetzt haben.

Anzahl Buchungen: \_\_\_\_\_

7d) Stellen Sie die Filter für den voreingestellten Zeitraum so ein, dass nur Lastschriften angezeigt werden.

### Author's Note

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### Non-Plagiarism Statement

I hereby declare that this thesis is my own work and that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Silvia Heinz

Basel, May 1, 2009