

Exploring Multiple Users Interaction With a Dual- Sided Interface

Aalborg University HCI

Bo Lind Jensen

7/30/2010

Exploring Multiple Users Interaction With a Dual- Sided Interface

Aalborg University HCI

Bo Lind Jensen
2013

Title: Exploring Multiple Users Interaction
With a Dual-Sided Interface

Affiliation:
Investigating Emerging
Technologies;
Dual sided interaction

Project period:
Master Degree, Spring term 2010

Project group:
d504a

Participants:
Bo Lind Jensen

Supervisor:
Jesper Kjeldskov

Print run:
3

Pages:
58

Appendices (number, type):
4:

Questions,
Documented statements,
Figures
Spreadsheets (raw data)

Synopsis:

This thesis deals with the exploratory testing of a custom created Dual Sided Interface conducted in a lab environment. The purpose of the study was to find and generate a basic understanding of the interactions performed individual people collaborating while presented with information from a custom created Dual Sided Interface.

Eleven test teams which each consisting of two people, were exposed to the same test. The test itself was having the participants read contents from a screen wherein data could be viewed from both directions at a time. Data charts such as Line, Column, Bar and Pie charts were used.

The tests were videotaped and that data gathered was quantified and grouped into different observational patterns, such as how many times the participants performed a flipping operation on a window. Furthermore it was observed that some people had next to no trouble reading content on the screen while it was being displayed in a mirrored form. The custom created Dual Sided Interface did not use a true multipoint implementation but instead a simplified form with let two mouse devices control a single pointer shared among the participants. This might have resulted in a lower interaction rate then had true multipoint been used.

The report concludes that that more research should be done, to establish the true usefulness of a Dual Sided Interface.

The contents of the report are freely available; however publishing (with source) must happen only by agreement with the author

Preface

This master's thesis was written during the spring 2010 by project group d504a from the Department of Computer Science at Aalborg University. The author is affiliated with the Human Computer Interaction group within the Information Systems research unit.

It is assumed that the reader has some basic knowledge of Human Computer Interaction and an healthy interest in emerging technologies.

Citations are written in quotation marks and italicized, longer citations are clearly separated from other text by indentation and spacing. **Bold** is used to ease reading in some places. All references are denoted by “(numer_in_refence_list)”.

Throughout the report the terms such as charts and diagrams used loosely but are meant as the same.

The report is structured as follows. First an introduction to the topic is given, wherein the general research question will be put forth. Then a presentation of the research methods applied for answering the research question is given, then the different components which went into the testing process such as the program, the people, and the data which seemed relevant is discussed. Then different observations from the results is highlighted and finally discussed before a conclusion is drawn.

The author would like to give thanks the people who volunteered to take part of this exploratory experiment to test the DSI. Furthermore the author would like to give a special thanks to Jesper Kjeldskov as the supervisor, for his patient and constructive feedback and not only going the extra mile but well beyond that, for this project to become a reality.

Bo Lind Jensen

TABLE OF CONTENTS

- 1 Introduction..... 1
 - 1.1 Background of the study..... 1
 - 1.2 Purpose of the study.....2
 - 1.2.1 Significance of the study.....2
 - 1.3 Research Question3
 - 1.3.1 Scope of the Study3
- 2 Research Methods 6
 - 2.1 Relevant Research Methods explained 6
 - 2.2 Research Purpose.....7
 - 2.2.1 Research Objective.....7
 - 2.3 Research Methods Used 8
- 3 Test Components Explained 9
 - 3.1 The Dual Sided Interface 9
 - 3.1.1 Program Design 9
 - 3.1.2 Hardware Setup..... 12
 - 3.2 Test Participants 13
 - 3.2.1 Participants Recruitment Guidelines 14
 - 3.2.2 Participant Data 14
 - 3.3 Test Assignments 16
 - 3.4 Experimental Rigor..... 18
 - 3.5 Data Analysis..... 19
 - 3.5.1 Minor Questions 19
 - 3.5.2 Video Analysis and Transcription..... 20
- 4 Results From the Test Data..... 22
 - 4.1 Investigating Flips..... 22
 - 4.2 Investigating Mirroring 25
 - 4.3 Investigating Orientational meaning..... 27
 - 4.4 Investigating the “Best” Chart 29
 - 4.5 Interaction could be hampered by implemenation..... 32

4.6	Discussion	35
5	Conclusion & Recommendation	37
5.1	Overview	37
5.1.1	Restatement	37
5.1.2	Review.....	38
5.1.3	Limitations of research.....	39
5.1.4	Implications.....	41
5.2	Recommendations	43
	Works Cited.....	44
	Appendix I: Questions and Graphs	45
	Appendix II: Cleaned Aftertalk Statements	49
	Appendix III: Flip and Mirror figures.....	51
	Appendix IV: Spreadsheets	53

1 INTRODUCTION

The focus of this thesis lies in uncovering interaction patterns performed by people who have to operate a novel user interface on an emerging screen technology, while they have to talk to each other about the content displayed.

More specifically it is centered on uncovering how people react when they are presented with a Dual Sided Display, and they have to come to an agreement on the content being displayed on such a medium.

The scenario of having multiple people interact with a screen that can be accessed from more sides than the traditional front side, might at first glance seem as far off future speculations, but emerging technologies such as the Organic Light Emitting Diode (OLED) screen already have the ability to let people see the same image from both front side and backside of the screen at the same time. Although the screen technology is here, not many interfaces have been created to utilize this exciting property. The applications and their interfaces being run on these dual sided screens are still created using traditional Graphical User Interfaces ideas which dates back to when the foundation was made with a program called sketchpad in the early 1963. The general idea of the program was later refined, and in 1983 Lisa the first personal computer with a GUI was sold by Apple.

In the future it could be envisioned that holograms could be used as interfaces. Therefore it is important to have some basic understanding of the challenges that arises when multiple people, can watch and touch the same thing from multiple angles.

This work strives to uncover what happens when an image on a screen can be seen from both front and back at the same time. While letting people have some basic interaction abilities.

1.1 BACKGROUND OF THE STUDY

In the last semester the author of this report, and research partner David Sebastian Bahr, sought to find and highlight the pitfalls when designing a Dual Sided Interface (1). Topics such as how people would interact with a type of screen, and how they would interpret directions such as left and right, and general things to keep an eye out for when trying to implement such an interface.

It was inspired by other works such as Frostwall (2) and Consigalo (FogScreen) (3), both having a “screen” which can be observed from either side, with the optical properties of content displayed being show as normal on one side, and as mirrored to the other.

Last semester a lot of time was spend trying to implement different ideas which could be executed on a Dual Sided Display medium, but they were scraped as implementation problems arose such as:

- How to make a general solution for a system wide plugin
- Trying to implement proper multiuser support
- Taking account for input redirection when using touch screens.

This semester the program and its application domain was kept as simple as possible and the focus would instead be placed on people's reactions when working with the Dual Sided Interface.

1.2 PURPOSE OF THE STUDY

The purpose of the study was to find and generate a basic understanding of interactions performed by two people collaborating while using a Dual Sided Interface. These findings could then later be used for further research or as development guidelines when working with Dual Sided Interfaces. The intended knowledge would be generated by documenting the behavior of multiple peoples actions, when they were presented with content in a Dual sided Interface, where they would have to talk to one another in order to come to an agreement of what the data they were presented with represented.

The Dual Sided Interface which the test participants would be working with had the same optical properties as the Frostwall & FogScreen, meaning that content was viewable from both sides of a screen at the same time, as opposed to a normal screen interface, which can only be viewed from one direction as the back of a screen is usually obstructed. The optical properties of a DSI makes it such that content displayed would look normal from one side, while it would be mirrored when viewed from the opposite side. The interface makes it possible to interact with the screen from both sides one at a time.

1.2.1 SIGNIFICANCE OF THE STUDY

The significance of this study could be that it could potentially influence other research projects, and hopefully contribute to bring more light to this dim area of Human Computer Interaction. And it might influence how interfaces intended for Dual Sided Displays are going to be designed.

1.3 RESEARCH QUESTION

As described the main goal was to find and highlight knowledge relevant to a DSI by observing peoples interaction in front of such device. Thus the research question for the project was stated as:

What would happen when multiple people had to interact and agree with each other about data presented using a Dual Sided Interface (DSI)?

An interesting point would be how two people were going to react when only one, of them could be allowed to see the content in its correct form, at a time. Do they take turns, or would one simply dominate the other? These are quite interesting topics, which has yet to be explored. And to the author's knowledge as of writing this no such study have been conducted.

1.3.1 SCOPE OF THE STUDY

In this section the scope of the study will be set, and thus narrowing down the domain which to explore.

Although the general idea was to observe people interacting with a DSI, it was also relevant to make a note of what kind of data representation that would be used in the presentation, such that future studies of DSIs' within Human Computer Interaction could be conducted and compared to this one.

The different data types which could potentially be displayed on a computer screen was grouped into the four categories of:

- Abstract data types
- Spatial data type
- Normal computer programs
- DSI intended computer programs

Abstract data was considered the kind of data that describes something which has no solid form, such as the stock market, or weather forecasts, generally speaking data charts made from various information sources. Here it would be interesting to see whether people would be

able to read and agree upon different data charts, or whether they could comprehend when a given diagram should be read the other way than normally intended.

The next type of data to investigate could have been **spatial data** representations which are about locational data, Cornell Universities (4) definition follows:

Spatial data is data pertaining to the location and spatial dimensions of geographical entities

Spatial data could also contain other information such as a house relationship to other entities (such as other houses or trees), and their shape and size. (5).

Thus spatial data could refer to maps, such as Google world, or floor planes for internal house planning. These would be very interesting concepts to test, by having multiple people decorate their house using a DSI, or even trying to guide a friend to the nearest point of interest on a map, or the nearest exit from a given position. It could seem easy to adapt to a map shown in reverse, it could be perceived as much harder to be guided by another person giving directions from the other side of the screen, without knowing whether or not the directions should be mentally flipped.

Another interesting area could have been testing a “**Normal**” **computer program**, which was simply thought of as an everyday computer program, making use of normal interface design decisions, such as buttons, text ,scroll bars, pull-down menus, etc. Tasks such as work applications, internet browsers, computer games, video chat, could be tested.

These programs have one thing in common, which is that they were intended to be used from one side and one side only. It would be very interesting to see if people would be able to use these kinds of programs on a DSI. Video and video chat in particular would seem very interesting, as they at first glance would seem of a lesser importance whether they were shown mirrored or not.

Lastly a **DSI intended computer program**, was defined as a computer program that was designing to be used in conjunction with a Dual sided Display, where it was thought of that special requirements needed to be taken care of for the program to be used on this kind of screen. The guidelines for constructing programs to be used on a DSI have yet to become standard and publicized.

All four areas were very interesting, and could each have yield interesting results, but at the same time it could be argued that each of these could easily stand as studies for themselves. So as to not make the same mistake that was made during the previous semester the projects focusing was directed towards investigating abstract data types, such as data charts on a DSI. These charts would be used as a medium to observe how people interpret visual data representations such as charts of various configurations on a DSI.

But only focusing on charts alone would leave to much room for a plethora of different chart types that could be investigated such as the known Gantt chart, used for project scheduling, or the lesser known Bubble or Radar charts, where sizes and distances between the bubbles matters, or different polygonal shapes in a spider-web chart would tell if a company was over budget in a given department. Thus focusing on the domain of charts was sill to wide and another cut would have to be made. Therefore it was decided that the four basic and most common charts (6) were to be used. The reason for this decision was to minimize the risk of having people who would be in doubt as how to read a given chart when it is presented to them. Thus the selection fell on the commonly known Line, Pie, Column, and Bar charts. An explanation of the four chart types can be read in 3.1.1.1 Chart types.

With the data types intended to be displayed, set. The hardware and software aspect could be explained. As previously mentioned it was not the intent of this work to create a general solution to the DSI challenge, but instead trying to gather knowledge by scratch the surface and see which little bits of information could be gathered. So rather than focusing on exotic input forms, such as multiuser touch screens, or near gesture recognition. A relatively simple form of multi mouse interaction would be used. An explanation of this can be seen in the Dual Side Interface section 3.1.2 Hardware Setup.

The program used to display the content was made using Microsoft's Expression Blend, which was built on the .Net framework, could take care of input redirection, which was one of the problems encountered in the last semester. A brief description of the program and the ideas that went into the layout can be seen in 3.1.1 Program Design.

With the general frame of the project set, it would be appropriate to make a note of the methods used to complete the project; this is done in the next chapter.

2 RESEARCH METHODS

The following chapter outlines the research method used for acquiring knowledge to try and answer the projects research question. Thus the project relevant methods are explained.

The research methods used in this report were defined by Kjeldskov & Grahams in their work on mobile HCI Research Methods wherein they summarized eight distinct methods (7). These methods were compiled from previous reviews done by Wynekoop & Conger on methods within the area of Computer Aided Software Engineering (CASE) study (8). And as such the methods highlighted underneath should be considered the standard when doing research within HCI.

The eight research methods are:

Case studies, Field Studies, Action Research, Laboratory Experiments, Survey Research, Applied Research, basic research, and normative writings.

Also Kjeldskov & Graham highlighted five different research purposes.

The five research purposes are :

Understanding, Engineering, Re-engineering, Evaluating, and Describing.

In the next section the research method and research purpose of the project are explained.

2.1 RELEVANT RESEARCH METHODS EXPLAINED

The two most interesting research methods in relation to this projects approach to data collection was considered to be laboratory experiments and basic research.

Laboratory Experiments were according to Kjeldskov and Graham, “*characterized by taking place in a controlled environment where it is possible to recreate the same situations*”. This seems like a perfect match with the goal of the project, which was to study the same situation with a lot of different people again and again, to see whether the majority would have the same reactions to a given scenario.

Advantages: The advantages of laboratory experiments were that it would be possible to control variables, and thus be possible to replicate the same situations.

Disadvantages: The disadvantages of laboratory experiments were that it could have a limited realism, and thus unknown how generalizable the results were going to be.

Basic Research was according to Kjeldskov and Graham, “*characterized such that it can be used to study well-known problems which no solutions are known.*” This again fits well with the concern of the project. Which were that this novel technology exists, but it is unknown how

people actually reacts when they had to look at different representations and then agree with another person looking at the same representation but for whom the representation was not quite the same because of perspective.

Advantages: The advantages of Basic Research were noted as there would be no restrictions on solutions, and that they could solve new problems.

Disadvantages: The disadvantages of Basic Research were that they can be costly, and time demanding, and in the end they might not produce a solution.

2.2 RESEARCH PURPOSE

To make the purpose of the study totally clear the two official research purposes of engineering and understanding were looked into, as the project would have to make use of both more or less.

Engineering is defined by Kjeldskov & graham, *as the purpose of research focused toward developing new systems or parts of systems such as e.g. an interaction technique for mobile phones*. Although it was the intent of the project to create a Dual Sided Interface and a screen such that these two could be used in conjunction to test peoples interaction, the engineering itself was considered a very small part of the overall researches purpose.

Understanding on the other hand which is defined, by Kjeldskov & Graham, *as the purpose of research focusing on finding the meaning of studied phenomena through e.g. frameworks or theories developed from collected data*. This goes very well with the intend of this project as it was intended to bring light to this uncovered area and understanding of dual sided interfaces and their interaction, by monitoring the people and coming up with theories dependent on the interactions watched during the tests.

2.2.1 RESEARCH OBJECTIVE

The objective was to observe how two people interacted with the DSI while they were presented with some form of data. This interaction and their talks and body language would then be interpreted into different observations. Some were to be expected prior to testing, but others might reveal themselves during or even after the testing was done. The Unexpected is only brought forth the by letting enough people run though the same test scenario enough times. These observations will then be evaluated on whether they are considered critical for future implementations or not.

2.3 RESEARCH METHODS USED

To answer the Research question of how people would interact with this novel technology basic research conducted in a laboratory environment with the purpose of understanding was chosen. Thus the project will be to conduct as an exploratory manner, in a lab environment.

Meaning that the test would be open ended, that it would be less important how long it took somebody to complete a given task, instead the interesting parts would unveil themselves after enough tests had been done and analyzed.

Thus knowing to simply run the test it was time to create the DSI and gather the test participants. This is what the next chapter is about.

3 TEST COMPONENTS EXPLAINED

In this chapter a description will be given of the different things that went into the test such as how the screen was made, and what the program was designed to do, and the different chart types used. Also a description of how test consistency among tests was upheld to improve testing rigor is described in this chapter.

The computer department at Aalborg University (AAU) has a state of the art usability test laboratory, which is equipped with multiple cameras connected to an observation room located behind a one-way mirror screen. This is the classic test setup for Usability testing according to (9). With this state of the art test lab it was possible to record both what was going on in the room, and on the DSI.

This environment should be deemed to be just as suited to conducting a structured exploratory test, as it is for its daily use in usability testing.

3.1 THE DUAL SIDED INTERFACE

The dual sided interface is composed of two components; the program and the hardware that it needs to run on. Both of these are explained below.

3.1.1 PROGRAM DESIGN

As previously mentioned it was considered a good idea to keep software implementation as simple as possible, so instead of trying to make a system wide implementation that could turn an already working operating system into a dual-sided environment, a small application was created. The test machine was using Microsoft Windows, and thus the program was created using Expression Blend which uses XAML code for the interface handling and C# for its code behind (functional). Expression Blend is the new way of making interesting new interfaces for Windows, as it has more features and less restrictions than using Windows forms.

The application was made to show pre created graphics (the charts) in a picture box, these images could only be changed with a key stroke. The program was designed in this way such that only the observer could change the charts, such that the test would only progress when the test observer wanted the test to proceed. This was done to make sure that one of the participants could not accidentally proceed before they had both given a clear indication that they agreed.

The image box was framed in another box which had the ability to do a tree dimensional flip animation. When flipped the content was mirrored using a function in the XAML code. Also a feature to enlarge and decrease a given area of the screen was implemented.

The buttons themselves look nothing like ordinary buttons, but it was considered that as the interface was to be used in this new context, it did not have to abide by old affordance rules or guidelines of how to place these. The buttons were designed with the thought that it would be hard to read text and instead they should have some kind of affordance meaning instead of a text label with a description.

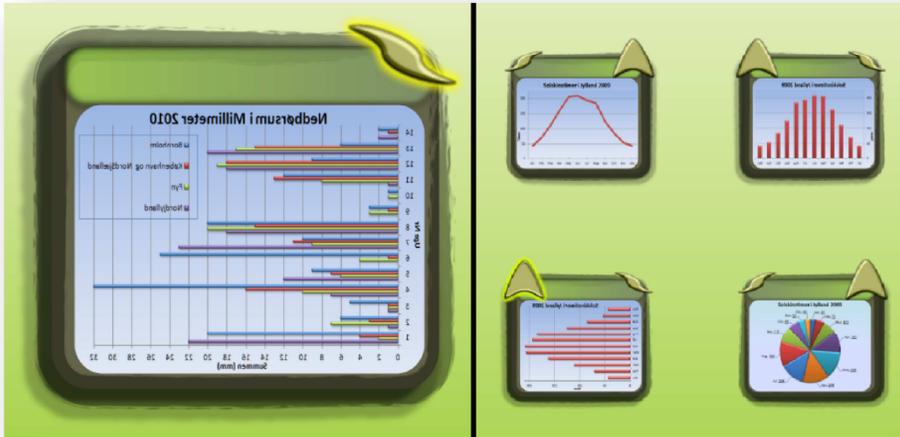


Figure 1: Program interface, showing the normal layouts for the primary test on the left and the secondary test right

An image of the running program can be seen in Figure 1 above, on the left a box containing a bar chart is displayed in its mirrored state with the mouse hovering over the flip icon. On the right side four boxes are shown, this is the layout used in the secondary part of the test. Here the enlargement button was added which made it possible to enlarge or decrease the box it was attached to. Also in the figure it is seen that the buttons change places if the box is mirrored.

Direct manipulation ideas were considered and utilized when creating the flip and an enlargement buttons, such that when the mouse was hovering over a button it would light up, to indicate that the mouse was in a hover position. Another state was when the button was clicked the icon would become indented. This can be seen in the box being flipped in Figure 2 below.

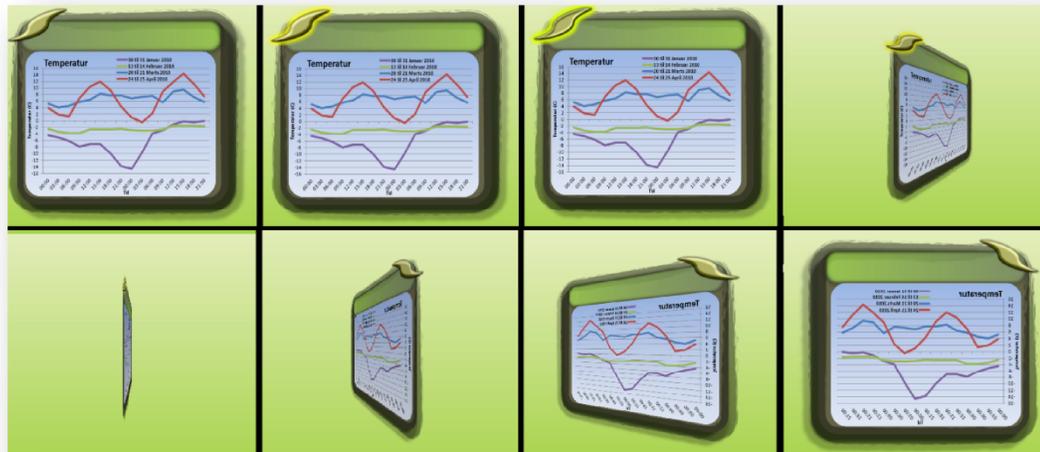


Figure 2: Flip function in action, showing direct manipulation with mouse over, mouse click, and flip from normal to mirror view

Also shown in the Figure 2 above is the flipping function in action. As the program was created it was noted that the flip could be considered as either **EgoFlips** or **CourFlips**, meaning simply that if a flip was done to spin the content such that the one initiating the flipping would end up seeing the display in its normal state it would be considered as an egoistic act, thus an EgoFlip. The other way was if the person performed the flip was doing it out of courtesy towards the other person such that they themselves would receive the mirrored state it would be called a CourFlip.

3.1.1.1 CHART TYPES & DATA

The different chart types used in the program will briefly be described. The four types used in this test were:

- The Column chart
- The Bar chart
- The Line chart
- Pie chart

The **column chart**, is used for observations over time, or under different conditions, it is best to keep datasets small, the column chart (vertical) is sometimes confused with the bar (horizontal) chart.

The **bar chart** is also used for observations over time, or when having different things that needs to be compared.

The **line chart** is very good at showing trends and is simply data points connected by lines.

The **pie chart** is a circle which shows how much individual parts contributed to the whole. The pie chart is only valid for one point in time.

The data sets used to create the twelve different charts for the primary part and secondary part of the test was actual weather data collected from the Danish Meteorological Institute (DMI). Each chart was converted into an image, to make sure that the charts would be the same in each test. This was done for consistency, as to minimize the risk of glitches in the program at run time.

3.1.2 HARDWARE SETUP

For creating the Dual Sided Screen, a video projector was used to light up thin layer of paper material coated on top of a transparent thermoplastic (Plexiglas) screen. The paper needed to be thin enough to let some light through to the other side, a normal projector screen is too thick for this to work. So for this implementation household baking paper was used. This type of paper would let the image be displayed equally well on both sides of the screen. Normal white A3 paper gave a much better image on the projector side, but the image was just as good as baking paper on the opposite side. This method was discarded as it broke the illusion of it being one screen, when one side looks better than the other. So baking paper was used.

The Plexiglas screen itself was put on a table and was given two clamps to hold it in place. The projector was tilted at an angle and had its keystone adjusted accordingly. All three tables were covered with table cloth to make the room cozier, and less sterile. An image of this setup can be seen in Figure 3 below.

Also people needed to be able to interact with the screen from both sides, each having their own mouse. As previously stated the focus was not on the input itself and thus the simplest form was used. So an approximation of multiuser functionality was setup, meaning that it was not true multiuser implementation. Instead two hardware mouse were sharing one mouse pointer on screen. It was done by connecting two computers in a LAN and then using Virtual Network Computing (VNC) software to let the client computer have access to the servers' application environment. The client computer then had its mouse x-axis inverted, and the mice were put on their respectable sides of the screen. It should be noted that this particular implementation of inverting one of the mouse signal only works if it is the clients' mouse signal that was inverted, it would not work if the servers mouse was inverted.

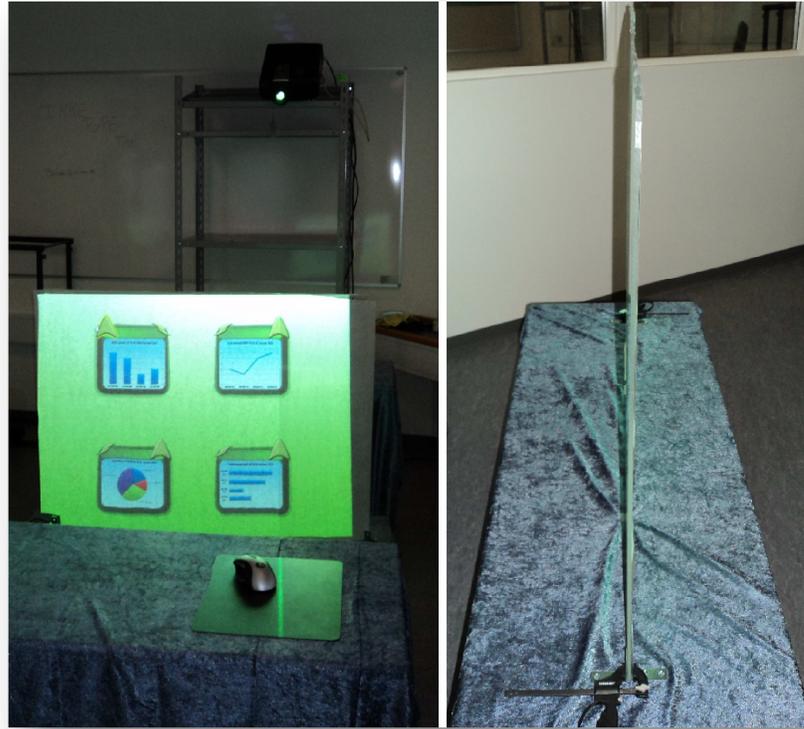


Figure 3: Showing the Hardware setup, from the rear and from the side.

3.2 TEST PARTICIPANTS

In this section it will be explained how the participants were selected and what the results of the pre-test questioners revealed about them.

In an effort to make the participants feel as comfortable as possible, prior to each test the different groups were offered refreshments, and fruit. Also the testing environment was made to look less sterile, by decorating the tables with table cloth, as Rubin & Chisnell describes it

Participants are often placed in awkward, stressful situations where they have little control over events. The more you put them at ease, the greater are your chances for accurate results that are applicable to real-world situations. (9)

Although results might not be applicable to the real world just yet, at least the chances for more interaction should be greater when people are feeling comfortable and are less stressful when conducting a test in the stress inducing lab environment.

3.2.1 PARTICIPANTS RECRUITMENT GUIDELINES

The people used in the test were considered from these guidelines

- Use a computer daily
- They had to be able to read graphs
- Preferably right handed
- Should know the partner they were paired with

The people had to know how to use a computer, as the test would involve normal interaction forms with a computer system using a mouse.

Also it was thought that the higher education a person might have, the higher the chances would be that a given person was able to read graphs, as they had to have seen the basic chart types either during school or in the news.

Right handed participants were preferred as the test involved using a mouse, which was configured for a right handed person, and thus it could give minor nuisances if a left handed person had to use the mouse.

The reason the test participants should know each other were concluded from previous studies, where it is seen that it can be hard to make Scandinavians talk to each other if they have no prior relations and had to be “pushed” to make contact (10). The project was concerned with mobile devices, but should still apply to some extent, to a lab environment where strangers are involved. So to negate this factor the test participants were selected such that they would know the partner they were being tested with. Thus they should have little to no problems interacting with each other. Then there is only the screen and the environment, left that could potential stress the participants.

3.2.2 PARTICIPANT DATA

From the questionnaire given to the participants prior to the test which were compiled into Figure 4 below, it can be seen that there was a dominance of male participants, of 18 to four females. All the participants were in their 20's with either a short or higher education's where the last was more dominating. And as it was considered that the higher an education a given person might have, the higher the chances were going to be that, that person would be able to read and interpret graphs. Thus participants thus far looked like the right mix.

Last but not least every the test participants did know the person they were going to be tested with, which also were one of the guidelines for which they were recruited from.

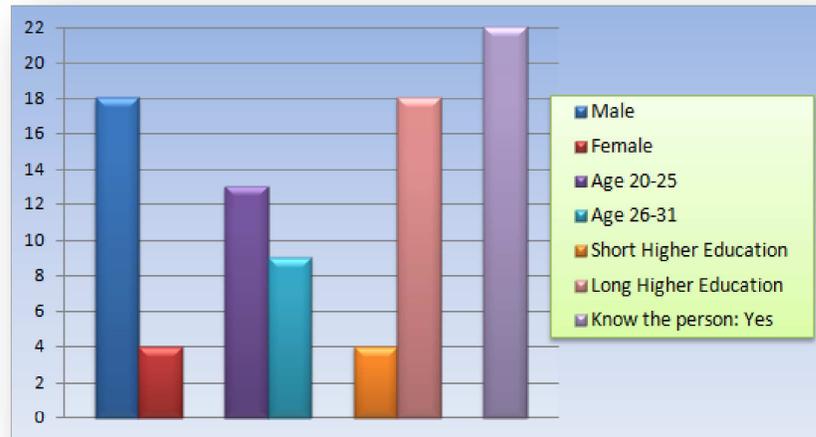


Figure 4: Showing information on the test participants

Not pictured in the chart are the two people were left-handed. Although it was preferred that the participants were right handed, as they should be able to handle a mouse configured for a right handed person, it was deemed to be acceptable as only two of the 22 participants was noted to have this deviation from the norm. Another fact not shown in the above chart was that only three of the 22 participants stated that they used a computer less than four hours a day, the rest of the participants stated that they were using a computer more than six hours a day.

It might not be the most diverse group of participants considering gender and age and education, but they should fulfill the requirement of being able to handle a computer, with this many hours logged.

Figure 5 below shows how the participants usually spend their time in front of a computer. It can be seen that almost half of the participants never used a spreadsheet environment, and that normal word processing, internet & mail tasks were quite dominating. This meant that on average the participants normally use of computers were for either reading something in the form of mails or internet sites. Or they were writing a document or mail etc.

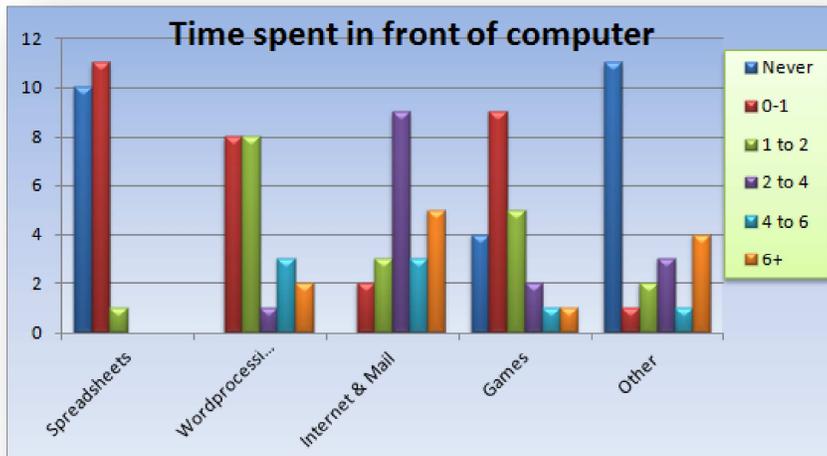


Figure 5: Shows how the participants normally spend their time in front of the computer (numbers are in hours)

Also at least 18 out of the 22 participants spend some of their time playing games.

In the category of other tasks 11 participants did not note any actions, and thus 8 out of the remaining 11, who noted other activities spend their time mainly for writing code, which again is a form of reading or writing text in the form of using letters and numbers. Only one explained that he spent some time on creating graphical images.

From this it can be gathered that only half of the participants were used to working in an environment where they might have created or watched data chart. Which was a bit discouraging as that was the focus of the test, to look at graphical data charts.

But it also shows that if another test was to be conducted of a DSI, it could be a good idea to spend more time in finding out how people would play games, or how people would do daily tasks such as writing mail and browsing internet pages.

3.3 TEST ASSIGNMENTS

The test was divided into two major parts; a primary and a secondary part refer to Figure 1 on page 10, for a reminder of the program design.

The **primary part** of the test had the participants looking at the four chart types: Line, Bar Pie and Column, in that order. Each chart type had three different assignment types and three

different data sets, such that the participants should have to understand new information, within the same chart domain as, they progressed on to the next assignment type.

The assignment types were divided into:

- Common assignments (read the question out loud)
- Participant 1 should explain the data for participant 2 (read internally)
- Participant 2 should explain the data to participant 1 (read internally)

In the common assignments both had equal responsibility to solve the assignment. And the assignment should be read out loud.

In the other two assignments it was the participant who read the question, who had the responsibility to solve the assignment. And here the assignment had to be read internally as to not give away too much to the listener as will be hinted at in 3.4 Experimental Rigor. In a testing environment where the assignments are given to the participants it is normally a good idea to have the participant read the assignment out loud to make sure that the assignment is understood. But in this case it was considered harmful to the overall testing experience, with two people testing the same thing, where one should know a bit more than the other.

The assignments would be worded as questions such as to read the maximum and minimum of a given graph, to see whether they could agree upon vertical dependent data. In another assignment they could be asked about whether the tendencies of a specific Line graph were rising or decreasing in a given interval, to see if horizontal dependent data would translate into problems for the person sitting in the mirrored position. Another was to ask the participants to tell the other person on which side of the given chart something was located. This was done to see if they would use directions such as left right top and bottom, or if they would solve it in another way. These types of questions were never specifically as to ask about left or rights, but which direction something was located in, or how something could be followed along the chart.

The assignments were considered from how people would normally engage in conversation about graphs if they were standing next to each other observing the same chart, and then wanting to tell the other person something about that chart.

The primary part of the test was by far the largest portion of the overall test.

In the **secondary part** of the test the participants were presented with the four chart types at the same time, and then they should pick one. It was designed such that both participants should agree on and pick the chart type they liked the best to solve a particular task. This assignment could be considered a bit artificial, as usually pie charts cannot be compared to line charts or column charts for that matter. Although artificial was deemed that it could still yield interesting results. The participants might be inclined to interact more with multiple windows than with just a single one, or they might not; testing was the only way to find out.

The assignments and the graphs used in the test can be seen in Appendix I: Questions and Graphs. Unluckily for the English reader they are in Danish, as this was the working language, but the assignments have not been altered, with the exception of made more compact to take up less space in the appendix section, other than that they are identical to the ones used in the test.

3.4 EXPERIMENTAL RIGOR

Experimental Rigor as described in the Usability Handbook:

“Requires you to retain the same condition from session to session”
(9)

And to ensure that the introduction given to each group prior to them being tested was handled the exact same way. The test leader had an orientation script which was read out loud to each group.

This script informed them of what they were about to be doing, it reassured them that it was the system and not the participants who were being tested.

When the participants were given their assignments it was in the form of cue cards. More information about the test assignments themselves can be seen in 3.3 Test Assignments.

Two pretests were conducted, prior to the actual 11 teams test. The first pretest showed that there were far too few questions for 45 minutes of testing, and as to not waste peoples time, two days of planned tests were canceled, such that more questions could be prepared and some of the charts made more clear, by adding axis information, and enlarging information on them were possible.

Another thing the pretest had shown was that when the questions were read out loud, the participant currently listening to the reader could answer the assignments well before the reader, for whom the assignment was intended too, had a chance to look at the chart. Thus the assignments intended for the reader was marked with a note not to read it out loud. The common assignments on the other hand had explicit text telling the participant to read it out loud. After these changes were made another pretest was conducted, which showed to produce better results, in the form of more interaction, and the official testing period could be conducted.

After each test unstructured Interviews were conducted, where the participants could vent their thoughts. Although the interviews were unstructured to let the participants speak their mind, they were still given basic questions such as what they thought about the screen and the experience, and finally whether they could envision some application area for such a device.

All the tests were conducted in the same test room with the door closed and the view to the outside blocked with curtains, to minimize distractions. The room light was dim to ease the viewing of the projected screen.

3.5 DATA ANALYSIS

The data which was intended to be gathering during the test consist of both qualitative and quantitative data.

Quantitative data which was deemed possible to collect would be the number of times a given person decides to use the flip function on a given window. Also it could be interesting to not only know how many flips were executed in total, but how many of those flips would be Egocentric Flips and Courtesy Flips, as in flipping for one's own understanding or to help the other person understand.

Qualitative data could be a bit trickier to get. This type of data would be gathered from interviewing the testing participants informally after each testing session, as to hear what they thought about representing data this way, and whether they could think of a better scenario to use such a screen. And videotaping the entire test would then make it possible to find patterns if enough people said the same thing, or if they acted the same way, given the same scenario. So the Qualitative data is gathered by watching the video tapes of each testing session, and if something out of the ordinary arises it will be documented and investigated, if multiple groups did the same.

3.5.1 MINOR QUESTIONS

While creating the program, setting up the screen and doing the tests, different things to look for revealed themselves and minor questions started to popup, such as:

1. When and why would people flip the interface?
2. Are people egoistic or friendly towards each other when using a DSI?
3. Can the person sitting on the mirrored side help, or even keep up?
4. How would specific positions on the screen be agreed upon, and is it even a problem?
5. Which of the selected four data types was best suited for a Dual Sided Display?

With these questions as a guide to answer the main research question, it was time to analyze the video material. The next section documents how the raw video data was quantified into different spreadsheets, for each test group which could then later be combined to find interesting patterns.

3.5.2 VIDEO ANALYSIS AND TRANSCRIPTION

The 11 tests were videotaped for the entire duration of each test which approximated 50-65 minutes on average. The video tapes were then watched and interesting parts re-watched, and the actions taken by the test participants were quantified and put into a spreadsheet by hand.

In the primary part of the test, the different states and behaviors quantified were:

1. What time did the assignment start (Recorded Once)
2. Was there any problems noted during the test (RO)
3. Who received the question (Recorded For Both)
4. What condition was the screen in at the beginning of the assignment, e.g was it mirrored or normal to a given participant (RFB)
5. How did the participants answer (RFB)
6. Whether they used the mouse to point (RFB)
7. Whether they read something from the screen while it was mirrored to them (RFB)
8. And how many courtesy flips they had (RFB)
9. And how many Egoistic flips they had (RFB)
10. And the total number of flips for the given test participant (RFB)
11. And then the total number of flips performed in a given assignment (RO)

1: The time was recorded to make it easier to find a given spot of interest later. **2:** Problems were recorded to see if it was the same questions or charts that gave the participants problems or not. **3:** Was recorded to later be able to see if the questions were consistently given out. **4:** This was recorded to make it easier to later see how the majority of the test had unfolded, column in the data sheet with the entire side was always reading “mirrored” would be a good indication that the person spent most of his or hers time reading something backwards, and vice versa if it instead read “normal”. **5:** To see if a person answered the question, or if they agreed. **6:** To see if there could have been some kind of pattern in how the mouse was used. **7:** To give a clear indication whether the participant read something on the screen while it was mirrored to them. **8:** Recorded to see how many times a given participant engaged in being friendly towards his or her fellow participant. **9:** Recorded to see how many time a given participant engaged in an egoistic act, to better one’s own interpretation of a given chart. **10:** The total number of flips for each participant. **11:** and lastly the total number of flips was recorded for each assignment to make it easier later to see which graphs were flipped.

In the second part of the test where the participants had the ability to enlarge or decrease the size of a given chart box, three more possibilities were put on the watch list. Such as:

1. Did the participant enlarge a graph, and which kind(s) (RFB)
2. Did the participant decrease a graph and which kind(s) (RFB)
3. And which type of chart did they think best fulfilled the assignment (RO)

1: Shows whether the participant was actively participating in the assignment or simply sitting back and not helping, **2:** Again to see whether the participant was engaged in the assignment or not. **3:** To finally be able to answer the question of which graph the participants used to best answer the given assignment.

Most of the qualitative talk and happenings were noted and if it was more interesting than normal, it would be highlighted for later reference.

Once this categorization was done the different aspects were put in another spreadsheet such that they could be compared. The information gathered in its raw form can be seen in Appendix IV: Spreadsheets.

In the next chapter interesting observations derived from watching and compiling 11 test sessions into data can be seen.

4 RESULTS FROM THE TEST DATA

In this chapter the test data will be investigated in accordance to the minor questions posed in section 3.5.1. The five parts that will be considered are:

- Flip
- Mirroring
- Orientation
- Best chart type
- Unexpected findings

First the flips mechanics were investigated.

4.1 INVESTIGATING FLIPS

To answer the minor questions concerning the flip function, posted in section 3.5.1 of:

When do people flip the component?

Are people egoistic or friendly towards each other when using such an interface?

Figure 6 below, shows the total number of times the windows was flipped, for each chart type, for a combined sum of 350 flips performed during the 11 tests.

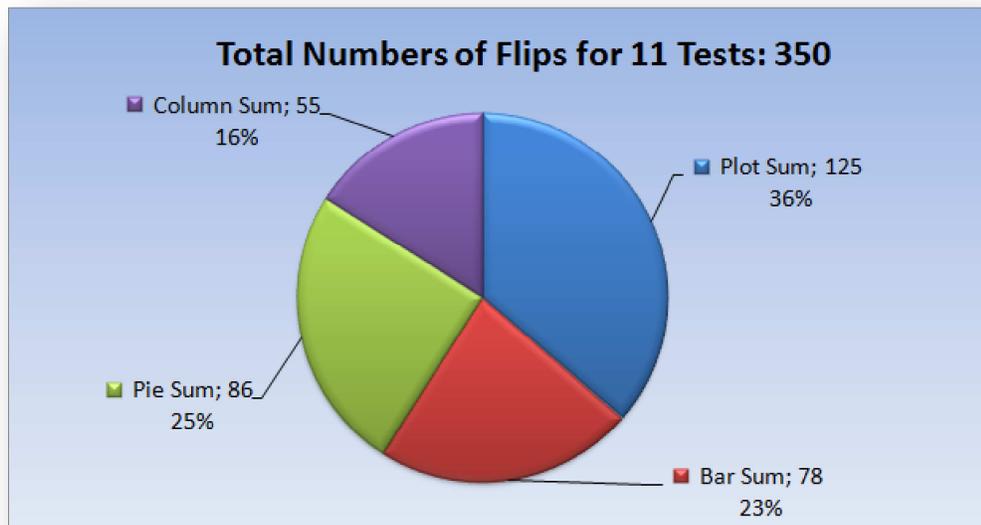


Figure 6: Showing the total number of times the display was flipped in the primary part, for both individual and common assignments

Also from this figure it can be seen that the majority of flips performed were done in the earlier part of the test, rather than the later, this could be an indication that either the charts were harder in the beginning, or that the participants were just getting to know the system.

But returning to the 350 flips which is just a number of little importance, when no reference has been established it would one such would be needed. Thus if the participants would as a bare **minimum** choose to flip the window once for every test assignment they were given, to either read or explain something to the other person. It would be expected that the 41 assignments, times the 11 teams would yield around 451 flips as a minimum amount of flips to be performed. Considering they would only need one flip per assignment to understand the chart. So with 350 flips it seems that participants were either lucky enough that the display was facing correctly in 100 of the tests, such as the need to flip did not arise, or the reference number might have been set to high, or it could be that case that the participants could solve the assignments without having the need to flip.

At three different instances in the test it could be observed that not a single test team decided to uses the flip functionality, two common and one individual assignment was completed without using a single flip. This can be seen in the in Appendix III: Flip and Mirror figures “Number of Flips Performed pr. Assignment”.

One of these cases namely the **individual assignments** of B3-2 and B3-3 was of particular interest as it yielded both the second highest flip score of 20 flips in an assignment, and zero in the next. This is interesting as both assignments in essence asked the same thing, but were just phrased differently. Both wanted the participant receiving the assignment to locate specific data readings on a pie chart, and then inform the other participant of these locations.

In B3-2 the question was formulated as to ask “in **which direction** on the chart” 4 distinct measurements were located, quite an unordinary question and as such could be the reason for the relatively high number of flips performed third overall with 20 performed flips. So something being confusing could be a reason to flip. The next assignment B3-3 which was given to the same person that had just received B3-2, the question was formulated as to ask “**where** on the chart” two measurements were located and how many % they each represented. This way of phrasing the question must have been a lot easier for the participants to understand, as not a single test group decided to flip the window during this process, even though this assignment asked the participant to read percentages of the chart.

But from further investigating the data it can be seen that eight of the total 20 flips performed in this test thought to be hard were performed out of boredom by a test participant waiting for his mate to understand the question. But that still leaves 12 flips which still is in the high end, of flips done in the tests. So a high number of flips could be a result of a semi complex graph, a tricky question, or just boredom, which was the case in the assignment of B3-2.

In Figure 7 below the total number of egoistic and courtesy flips are shown. Both charts seem to have the same tendency and as such it is hard to say anything from this. But it is noteworthy that TP1, meaning participants sitting on the original side, had almost 20 more flips of either kind than TP2. It could be that more people with tendencies towards play were sitting on the TP1 side.

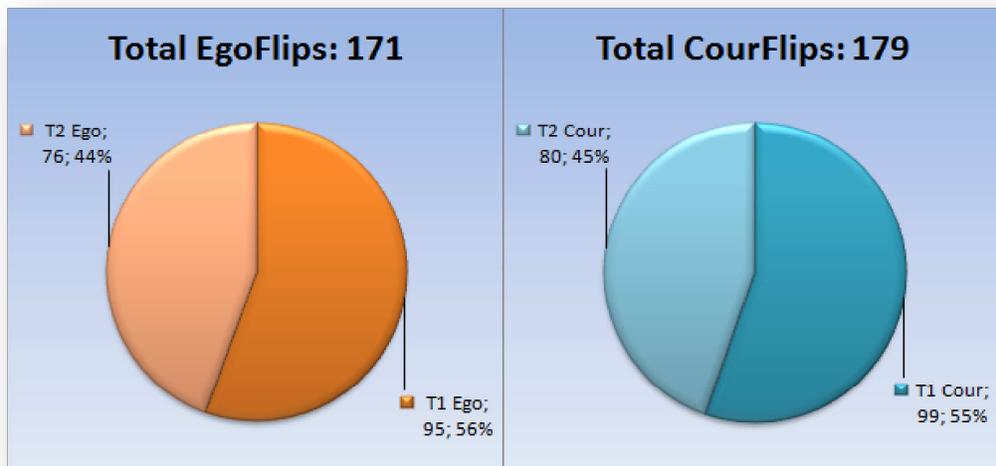


Figure 7: Showing the dispersion of egoistic and courtesy flips in the primary part of the test

But it looks like people overall did understand that in order for the other person to read the display it would need to be flipped towards him, as the marginal higher CourFlip count indicates.

When investigating the flip count for the secondary part of the test it can be seen that next to no flipping of the different windows occurred as the average flip count was two times pr. test group. Only in three of the 11 tests did the flip count actually go higher. The three cases that differ each had a flip count of four, seven and 14 respectfully; the most interesting of these were the one that made up for 14 flips. And in this session it becomes clear that the participant was clearly playing with the interface and not trying to understand the data, as he wanted to determine whether the windows would flip individually or everyone at once, and in the process used six of seven flips performed in the he first assignment, and in the next assignment only 4 more were used and then the display was hardly flipped again.

And as such answering when and why the display was flipped is a complex question, but generally it could be traced back to any of the following; a tricky questions, a complex chart(with mush information), and playfulness in one of the participants.

As the videos have been observed, a general consensus has been to turn the display towards the person, who receives the assignment. But one thing that is more consistent than the others were that when one of the participants received an assignment, the other person would CourFlip the display towards him, in the case the display was not already facing in the assignment holder's direction. In other cases if the display was not friendly flipped, then the person with the assignment would state towards the other person that he was taking now taking the display and thereafter performing an EgoFlip. And once the assignment and chart was understood, it was usual to perform a CourFlip, and then explain the components of the chart.

So the most consistent flip tendency was to understand, and then flip it back to explain, and from the limited deviation between Cour- and EgoFlips it can be said that people were at best neutral, but did understand the concept.

But as was also seen some assignments which were solved completely without the use of flipping the window, and as such the participants might have been able to read it while it was mirrored to them.

4.2 INVESTIGATING MIRRORING

To answer the minor question posted in section 3.5.1 of:

Can the person sitting on the mirrored side help, or even keep up?

Trying to answer this question was done by investigating the gathered data concerning whether a person was speaking about something on the display while it was mirrored, or he had just flipped it and explained new things. This ability was to be considered as a mirror reading.

The data was qualitatively gathered, by making a note each time the person watching the display in its mirrored state spoke about something on the display. The person might have said multiple things about the display, but it would still only be logged as one mirror reading, thus each assignment could have a maximum of two mirror readings, translating into one for each participant.

The mirror reading data was only considered for the primary part of the test and not for the secondary (multi-choice). As the second part of the test simply did not have enough flips performed to make a sound case, as previously explained in 4.1 about the relatively low flip count in the multi-choice test. If one wanted to it could actually be argued that the people used mirror reading to a much wider extent in the second part of the test than in the primary part. But this should be left to other projects to determine whether people learnt to read mirrored or whether it was other influences such as four windows that could have had an impact.

So returning to the primary part of the test which the mirror reading data can be applied, it was seen that during almost entire tests one of the participants figured that it was easier simply to do nothing and explain the graph while it was displayed in its mirrored state. And as such no flipping of the display occurred, looking at the “Flip Counts & Mirror Readings” figure in Appendix III: Flip and Mirror figures, will reveal that that was the case. More information as to why this could be happening was revealed during the after talks which are further explained in the discussion section 4.6.

By using data about total number flips performed per chart type and comparing that with the sum of mirror readings for each chart type as has been done in Figure 8 below. It can be seen that the sum of total number of flips performed in each assignment went down, as the number of times the participants was observed engaging in mirror reading. The slight bump in the Pie assignment shows validity in this observation. As both are affected, when either the flip count goes up the mirror viewing goes down.

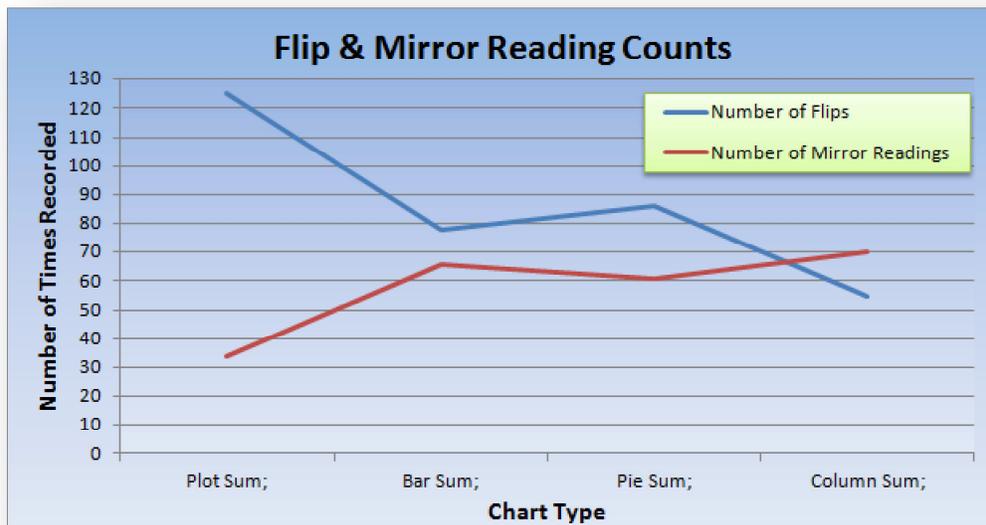


Figure 8: As the number of mirror readings goes up the number of flips goes down or vice versa

As the number of mirror readings was recorded much more subjectively by having the analyst listen for it to happen this value is much more prone to errors, meaning that there could easily be more mirror readings done in the actual tests than was recorded on this figure, some could have been missed.

And as to answer the question, it would seem plausible that some people would be able to help and keep up even though they were presented with data that was mirrored to them. While others clearly stated that they were unable to read anything mirrored.

4.3 INVESTIGATING ORIENTATIONAL MEANING

To answer the *minor question posted in section 3.5.1* of:

How are specific positions on the screen agreed upon, and is it even a problem?

To try and answer this question data gathered in the multi-choice assignment (secondary part) and from the first one will be looked at.

In multi-choice assignment A6-1, TP2 wants to look at a specific graph and asks if they can use "the first one up there?", [looking at the column diagram, which is in the upper left corner for TP2] TP1 enlarges the Line diagram [which is the first according to his point of view, as it is in his upper left corner] Just as the enlargement process is taking place TP2 utters; "The one up on the left!".

A transcription of the scenario follows:

1. TP2: [Reads question] "We need to agree on the months where less than 75 hours of sunshine was registered."
2. TP1: [Takes control of the mouse]
3. TP2: "is 75 like... ehh ehmm .. like a bar"
4. TP1: [Moves the curser closer to the enlargement button of the column diagram]
5. TP2: "on **the first one** up there?"
6. TP1: [**Moves the mouse: From the column diagram to the line diagram**]
7. TP2: "the one.."
8. TP1: [Enlarges line diagram]
9. TP2: "..up **on the left**" [with his left hand TP2 makes a gesture towards the column diagrams position]
10. [Line Diagram fully enlarged].
11. TP2 "No, there is no bar
12. TP1 Nope no bar, [Mouse click: Zooms out from the line diagram]
13. TP2 "naaaa.."
14. TP1 " what about the other one over here, [Mouse click: Enlarges the column diagram]
15. TP2 [mumbles] ye 75....

Figure 9: Assignment A6-1 Test Participants JJ

From

Figure 9 above it can be seen that TP2 wanted to have the column diagram enlarged, and as he could see TP1 was about to enlarge the wrong one TP2 wanted to correct, but it was too late as

TP1 was already zooming in on the line diagram. Not only was TP2 late in uttering his request it was also a wrong command, as he did not take into account of whose left it should be addressed too. From studying the video it becomes clear that he meant his own left, as he made a gesture in the left direction.

Also note that TP2 actually asked TP1 to look at **"the first one"** which ever that might be in a dual sided environment. This could pose a problem, as the first one normally implies the top left, when ones native language is English or Danish which is read LeftToRight, but then other countries where text is read RightToLeft such as Arabic or Hebrew could have the same problem except the first one would instead mean the top right corner instead.

So one should not refer to a location on a DSI as the first, or for that matter the last one as it would no doubt lead to confusion.

In another assignment the participants were asked to locate different information on a pie chart and then relay where on the chart they wanted their buddy to look. Figure 10 below highlights the diversity shown by the participants, as they gave these directions. The assignment never said anything about how to accomplish this task, only to tell the other participant where on the pie chart something was located.

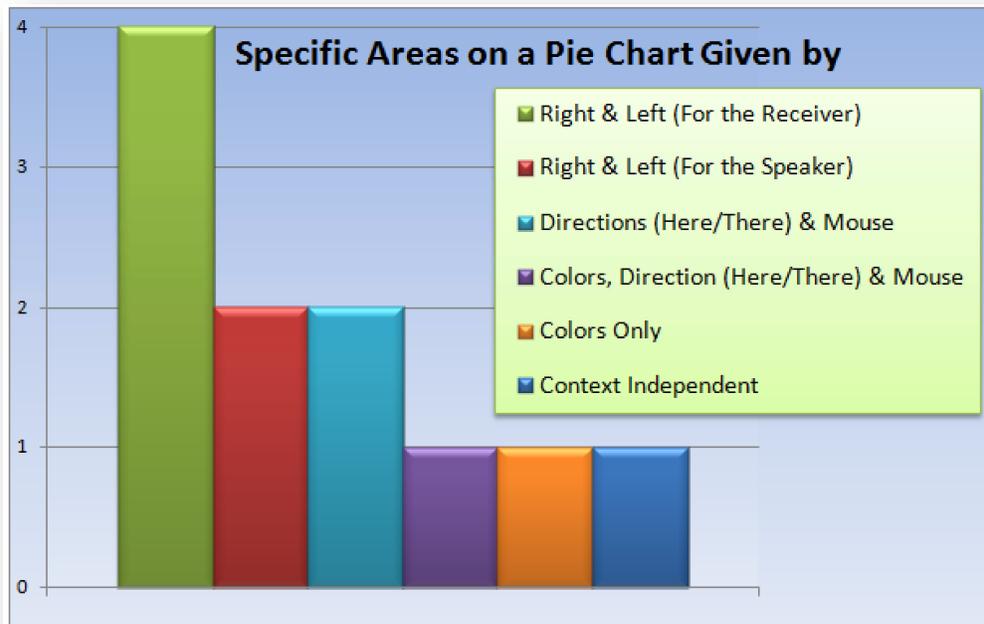


Figure 10: Shows how the participants stated directions for assignment B3-2 (Pie chart)

In four out of 11 cases it was done by relaying the message with left and right for the receiver, meaning the person trying to give direction had already mirrored it in his own mind.

In two of the cases the speaker simply said that it was to the left or right, for his point of view, and then it was up to the receiver to translate that into useful directions.

In two of the cases the mouse was used to point and give vague directions like the information is located, “here” or “there”. In another case the participants decided to add color to make it even clearer. Giving directions like this works when having a mouse pointer.

In one particular case the test participants found a context independent reference point outside the display medium, and could then say near the windows, or near the control room. This gave them a common reference outside the screen.

The test showed that that there is no consent in how this type of information should be relayed to the receiving part. So a standard way of doing this should be put forward and agreed upon. The standard proposed here is not the one the majority used such as always mirroring one’s own response for the receiver, or using directions and the mouse to point, as sometimes a pointing device might not be present. So instead it should be the one thing that after some thought actually seems the most logical and seems to work the best in any given situation with two people observing such as screen, which was the peculiar case of **Finding and using a common reference point outside the screen.**

It should always be possible to find some object on either side of the screen, and then be able to talk about information on the screen using these. So it is proposed that the idea of using a common context free reference point should be used instead of left and right or other directions when talking about content on a DSI.

4.4 INVESTIGATING THE “BEST” CHART

To answer the *minor question posted in section 3.5.1* of:

Which of the selected four data types is best suited for a Dual Sided Display medium?

The data created from the secondary part of the test, where the participants had four different charts to choose from, is looked into.

The idea was that the participants should pick the chart type they liked the best, and use it to answer the assignment. The test itself was a bit artificial as it compared pie charts with line chart, two chart types, which normally are not used in conjunction as one displays percentages of a whole, and the other trends over time and as Ellis & Dix points out about visual representations is that:

“Different visualisations deal with different kinds of data”. (11)

&

“Different tasks are better supported by different visualisations” (11)

So it might not have been the best idea to focus on the “best”. But Ellis & Dix might give a clue as to why the line chart was only picked one time out of the 99 times a pick was made. It could imply that the assignments and data sets used were simply not good enough to make the line chart stand out as useful in any of the assignments it was involved in.

A funny fact when reviewing the data is that the one time the line chart was actually picked it seem like it was done on the account of miscommunication, as the two participants were discussing which of the diagrams they liked the best and one of them said that he liked the one in the top right corner, and then said your left corner. But looking confused as it was picked. Had he instead used a common object in the room as references, as previously discussed, this error could have been avoided and the column chart would have had one more added to the list.

But as that was not the case the column chart had to be satisfied with “only” being selected 58 times out of the 99 possible, which is roughly 59% of the time, which could imply that this chart type must be really good at displaying information on a DSI. But while looking at this test one has to make a note of something which at first glance could be a bit embarrassing to highlight. Something in the test which should not be able to go wrong did go wrong. In three of the 11 tests one of the Column charts, occupying the Top Right Corner of the screen, when viewed from its original side, was instead displayed as a Bar chart. This alone could be cause for discarding the result, but looking a bit closer an interesting discovery looms just beneath the surface.

It could be that there were other reasons the column chart seemed so much “better” than the rest, and one reason could be have something to do with the position it occupied during the test.

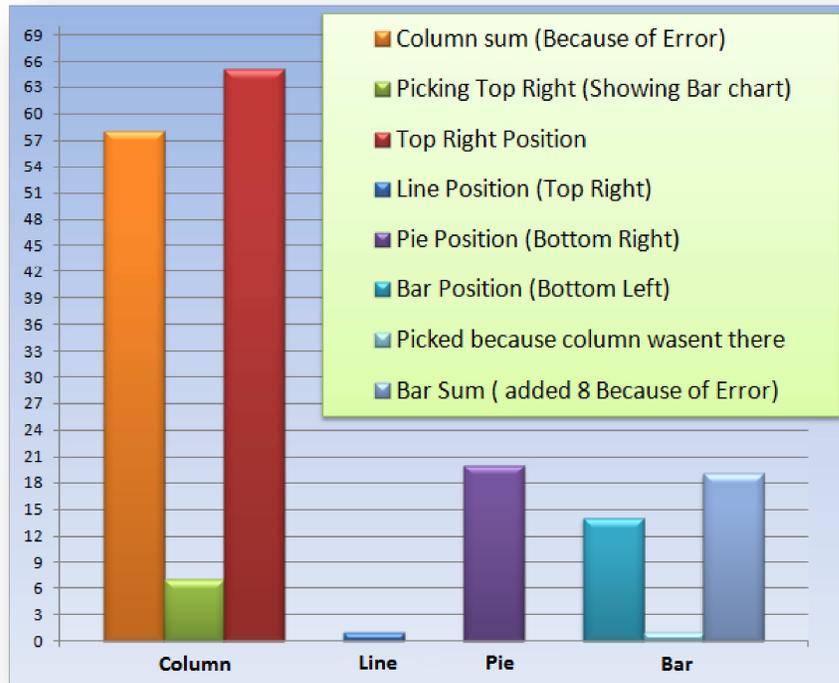


Figure 11: Showing the chart most favored amongst the participants

As seen in Figure 11 above, in seven out of nine possible cases where this error occurred the top right position was still picked even though it was erroneously displayed as the bar chart. In one case this position was still picked even though one of the participants wondered why it was now a bar chart instead of the usual column chart. When these numbers are added together considering the position instead of the chart itself the top right position was chosen 65 times out of 99 which approximate 66%.

Multiple factors could be influential towards this;

The test leader could have unconsciously pointed towards this position as he explained the resize function.

The test participants had just finished the primary part which ended with a column chart, and thus they were more open to use it again.

Also from looking at the data it could seem the first question in the secondary part of test was heavily influential towards picking either the column or bar chart, as those were the easiest to read for this particular assignment. All, except one, group picked the columns, the last picked the bar chart. This could have subconsciously instructed the majority of the participants in liking the column chart more from the start.

Or it could be that the chart simply was better looking, then the others, even though it was strived to make them as equal as possible.

Although the test did not yield a clear answer it facilitates the formulation of an interesting question such as.

Does the position of the content on the screen matter more than the actual content displayed?

4.5 INTERACTION COULD BE HAMPERED BY IMPLEMENTATION

An unexpected observation was made, which could have had an impact on the total number to flips and the overall amount of time the mouse was used as a pointing device.

It could be theorized that the simple implementation of multiuser properties, where the participants shared a single pointer on the screen, might have had a hampering effect on the intended interaction.

It can be seen by observing the participants as some are asking for, and giving permission when they need to take over, or give away control of the mouse pointer. In other cases one side is seen as becoming almost completely passive and not touching the mouse for a period of time.

The following three cases illustrate this point in the form of:

- Coursing
- Thinking outside the box
- And never letting go of the mouse.

In the first example the **case of cursing**; both TP1 and TP2 has been reluctant towards using the mouse, TP2 has mainly been using the finger to point, which could be a bit funny as the screen was not transparent and as such TP1 was never able to see this. But later in the test period TP1 has control of the mouse and TP2 finally wants to use the mouse and the following unfolds.

TP2 [asks for control] "I'll just take over the mouse"
TP1 "Ok"
[TP2 tries to move the mouse, but TP1 still has his hand on the mouse]
TP2 "You have to let go of the mouse you [explanatory]!"
TP1 "ohh right [laughs]"

Figure 12: Assignment A5-2 Test Case CD, Coursing

As

Figure 12 above illustrates TP2 wants control and is given the control, but then becomes angry as he finds out that control was not truly given.

In the next example “**Thinking outside the box**” a more friendly approach is taken to the same kind of predicament.

TP2 [Is given the question, while the screen is mirrored towards him]
While TP2 reads the question TP1 Courtesy Flips the window [directly yielding control to TP2]
TP2 then points with the mouse at a red spot
TP1 sees that there is another red spot
TP1 [sitting on the projector side] raises his hand into the projection cone, and uses his shadow to point .
TP1 “you were using it” [referring to the mouse, laughing].

Figure 13: Assignment A3-2 Test Case GM, Thinking outside the box.

From Figure 13 above it is seen that TP2 did not initially have control of the mouse, but was given this control by TP1 when he courtesy flipped the window. Then as TP1 had given his control of the mouse and window away, he found it difficult to ask for it back. So instead he “broke the matrix” so to speak, by using the shadow created from placing his finger in the projector cone as a pointing device. The pointing with fingers have been observed in multiple cases throughout the testing period and it is unclear whether the majority are related to their being a control issue when only one pointer is used, or if that was simply how people would look at data.

In another assignment (multi choice) the test participants have gotten the idea that they needed to explain their thoughts about each chart. It can be seen that TP2 has control of the mouse to begin with, but then TP1 is allowed to take over and TP1 keeps mouse control for the remainder of the session, (The test leader was about to stop them, but lets them continue.)

TP2[who has control of the mouse from previous assignment] starts with enlarging the column diagram [his top left corner], and finds that it would be easy to answer the question using this.

TP2 then “allows” TP1 to explain the next graph [test leader is about to stop them here].

TP1 zooms in on the line diagram [his upper left] and says; “it is kinda’ the same, but a bit harder to read, as it does not have interval bars”, TP2 “yes it is a bit harder to read the months directly”.

TP1 moves on and enhances the row diagram, [his down left corner], and they agree that it is almost the same as the column, but TP1 says: “it’s a bit harder to agree upon as we can be confused with left and right when it lies down” TP2 thinks that applies to the others as well.

TP1 then enlarges the pie diagram [his lower right corner], TP1 is quick to dismiss it with the comment “that one is absolutely not easy to read” [it is mirrored to TP1, and there is a lot of text in it] and zooms out, but TP2 wants to see more so he gets TP1 to enhance it again, after some talk they agree that it cannot be used, although TP2 is less dismissive of it, TP1 then minimizes it again.

TP1 zooms in on the column diagram again [his top right corner] and says that this one is the easiest if they both have to read it, TP2 agrees.

Figure 14: Assignment A5-1 Test Case JJ, Never letting go.

In Figure 14 above it is seen that control is given TP1 to explain the next chart, but instead of explain the next and return control back he keeps the control and explains the rest of the charts. All the charts, except the bar chart, were mirrored for TP1 and thus it is noteworthy, that the participants in this snippet did not flip any of the graphs when they had the mouse control, and only used it as a token of who would be allowed to speak.

From other assignments it would seem as if the participant receiving the assignments naturally has the right to control the mouse. This was an unintentional side effect of using this simple form of multiuser implementation, and could have had an impact of how the sessions were conducted. As there are indications towards it being harder to just simply take control of the mouse, when the other part already is in possession of that control.

4.6 DISCUSSION

This section is intended to elaborate further upon some of the topics already investigated, with the added information gathered by interviewing the participants, their statements can be seen in Appendix II: Cleaned Aftertalk Statements.

The issue of not flipping:

As stated some of the reasons not to flip the window were simply that some of the participants could read the content while it was mirrored, or had already gotten a complete mental picture of the content, earlier while it was facing them correctly.

Other reasons for not flipping the window was that some found it tedious to move the cursor from one corner to the other, as the flip button changed position from mirrored to normal view. Instead they would have liked the button to have stayed in the middle. This contradicts a direct design decision of having the button move from side to side as the window rotates. But some people did not like this.

A third reason not to flip the window was that pointer information would be lost as the cursors position did not flip in accordance with the window. And it would be equally hard for the participants to find the data location again once the screen was flipped, and even in its mirrored state to the one trying to explain the position.

Some of the participants thought the flip function was only useful as an introduction mechanic for new users, and could easily envision implementations of this type without the ability to flip the contents.

Reasons for not using the mouse more:

The implementation of the multi mouse using the LAN setup made is such that the cursor sometimes could jump a little dependent on who used it last. Some found this imitating. Thus some people stated that they would have used the mouse more if it had provided a true multi pointer function such as giving each participant their own on screen pointer.

And as previously described it was not needed by to some as they could easily read the display in its mirrored state.

Others found it hard to take control of the mouse.

In other observations it can be seen that there might be a control element when only one pointer has to be shared, and this might have diverted focus from the actual DSI testing. As the single point sharing could have been a self-confined test.

On future screen usage:

When asked what they thought that this screen could be used for most of the participants did not think it would be useful for anything, they could not see why information would ever be displayed in this way rather than them sitting next to each other and interacting with a screen from the same side, just as in a typical setup. But some could find reason in the argument that two people could not occupy the same physical space and as such would not have the same view of the content displayed on the screen.

When pressed further for an application area most people either answered games like chess or checkers. Or that it could be useful for drawing images for recreational purposes, and not so much for professional use, although some idea was to use the screen as a brainstorming device where it was possible to draw on the same model.

It could be perceived that the challenge with the DSI is not so much that the content is sometimes mirrored; but that the participants does not have a vocabulary to properly talk about data represented this way. The participants simply cannot talk about the data in unambiguous way to make the other person see. This challenge is most visible when horizontal dependent data is used.

Also the general consensus from the participants after the test was that the testing period might have been a tad bit too long and the tests tedious. The testing periods were also quite long, in one instance a test person uttered discomfort with then number of tests left after only 7 minutes and 15 seconds, this could be considered a bit quick, But the same person stated this again four times in during the session, but did complete the test. It could be argued that the test was quite too long and that it did put a lot of strain on the participants attention span as well as the test leader sitting in the room, who were experiencing the same process for 11+ number of tests.

5 CONCLUSION & RECOMMENDATION

In this chapter an overview of the project, and restatement of the problems and a review of the findings, will be given. Then we will talk about the implications of these findings, and finally we will give a description of the limitations of our research and finally some advice for future tests in this given domain.

5.1 OVERVIEW

The project was about trying to light up an area of human computer interaction which has not seen much interest, namely the interaction between people while they are operating a dual sided interface.

5.1.1 RESTATEMENT

The goal of this project was stated in 1.2 which was to find and highlight knowledge relevant to a DSI by observing peoples interaction with such a device, and the overall working research question was stated as :

What would happen when multiple people had to interact and agree with each other about data presented using a Dual Sided Interface (DSI)?

As this was quiet and open ended question even after narrowing down the scope of the project in section 1.3.1.

It was allowed as such, as the project was using a research method with explorative approach and the mindset should be in the form of ill know it when I see it. So during the process of creating the DSI and the assignments for the test the minor question were posted in section 3.5.1. These could were:

1. When and why would people flip the interface?
2. Are people egoistic or friendly towards each other when using a DSI?
3. Can the person sitting on the mirrored side help, or even keep up?
4. How would specific positions on the screen be agreed upon, and is it even a problem?
5. Which of the selected four data types was best suited for a Dual Sided Display?

The minor questions were then used as a guide for points of interest in the data gathered and each of these questions were then investigated and tried to be explained in chapter 4. And uncover some smaller parts of the research question.

5.1.2 REVIEW

This project was only a small piece in a larger puzzle of figuring out the DSI, and the work conducted could have potentially have created more pieces in the process.

As previously stated the participants used in this study mostly consisted of male students with a higher to long education, from the questionnaire it could be learned that they were not as fixed into charts and they were with using the computer for writing. And thus if another study should be conducted it could be interesting to see how much normal information could be displayed to people on such a screen before they would give up. Also it was a very conscious decision to have the participants paired up with their friends, this was done to minimize friction which otherwise could have hampered interaction if two strangers placed in an already stress inducing lab environment, were forced to collaborate another stress inducing stranger. Thus friends were chosen. Although friends could bring such concerns as hierarchy, or that one did not want to embarrass one self, and thus said nothing.

The participant's initial reaction to the novel idea displayed in the screen and interface were positive. But they were less pleased with the assignments themselves as they became tedious. Some did not understand the concept of the screen at first and asked why they had to see the content in a mirrored form instead of normal form.

During the thesis, different components of the test have been highlighted such as how friendly the participants were towards each other while using the interface. And it was shown that determining the when and why the display was flipped in a given situation could very well be a complex matter. But still a general thesis was put forth that the general form of interaction with this custom DSI while doing collaborative work was to flip the content such that it faced the one who needed to understand it and then flip it back once understanding was reached, and thus the content could be explained to the listener while he saw it in its original state. In other cases where the participant was able to perform mirror readings the display was not flipped, both as a friendly act, but also for some the act of flipping itself was seen as a minor nuisance because of the way it was implemented, where more specifically it was when the buttons changed position when flipped, and that the mouse cursor did not also become flipped.

In an interesting case when observing how the participants were talking about data by using directions it was found that using a common reference point which was outside the screen environment could do away with ambiguous signals such as left and right which are horizontal dependent in relation to the person uttering the directions. Some solved this by adding for whom it was left or right. But still the best way of doing this would have to be by using a common reference. This should be put to the test in future studies.

Also observing the participants trying to pick the “best” charts from the four chosen types yielded yet another question instead of answering the original stated question, which arguably could never have been answered according to Dix and Ellis (11). But instead of finding an answer a new question which if not as interesting as the original, was much more relevant in the context of Dual Sided Interfaces which concerned whether the position of the content mattered more than the actual content itself. This should be a concern which would be investigated in future studies.

The interaction for the interface was created in such a way that two mice were used to guide a single pointer on screen, this was noted to have a dampening effect on the overall eagerness to interact with the screen. Had another interaction form such as implemented true multipoint support the participants uttered that they would probably have liked it better, also if it would have been touch based the participants would have liked it more.

The research method chosen to guide the work was deemed appropriate from the perspective that prior to the test it was not clear what to look for. Some ideas did pop up along the way and thus followed. The premise of basic research is that it can be used to document and create theory about concepts which are not yet totally clear. And thus fit the project perfectly.

The way the data was generated by watching raw video was not the most optimal way as a lot of hours was put into transcribing a lot of data which in the end did not make it into the report but then again that could be considered one of the weaknesses of conducting basic research, which is that one might end up with nothing or at least very little.

And with almost as many questions raised as has been tried to be answer the biggest contribution this work could hope in an academic sense would be to inspire other research groups to conduct research within the area of HCI with its main focus on Dual Sided Interfaces, such that the effect upon the users could be understood a bit more. And the inner workings of people who are undertaking collaborative work and interacting with a Dual Sided interface. Understood.

5.1.3 LIMITATIONS OF RESEARCH

The work presented in this thesis has a number of limitations.

With 11 test teams used for study, equaling 22 people, it is fair to say that a relatively small sample size was used. In future tests more people should be exposed to this type of interface to get clearer indication of how, people think, and react in accordance with such a novel interface.

Also most of the test participants used in this study had a higher grade or longer education, and as such only using academic people might not give the best indication of how such a screen would be received in the real world. In future tests more social layers should be included. As

these could have a harder time overall, or they might even be better to reading mirrored, one can only know if it is tested.

Another limitation of the test process was that the content on the display could remain fixed in one direction for multiple assignments, and thus it would not encourage the test participants to flip the content. This could have been one of the factors as to why people flipped the content so little. So with more control given to testing leader, such that he could decide which direction the screen should be mirrored from, could encourage the participants to flip the content more. A simple rule could be implemented that stated that the content should always be mirrored to the participant who got the assignment, could give a better indication of whether people would start to flip, or simply do more mirror readings.

Also creating more interactive assignments which mimics the secondary part of the test could get people more involved with the test, rather than simply having to decipher a chart, and then read it, as this seemed to become very tedious, and the participants might have lost a bit of interest in the later parts.

After analyzing the tests it became clear that the assignments were not given in the same order in each test run, and thus it became harder to say specifically why one side would flip more than the other, as it could be because they were given more assignments.

Another problem could be how the test leader sitting in the room with the participants, acted during the test, and where on the screen he pointed when explaining something.

As previously described in 3.5.2 no tools were used in the collection of data, other than videotaping each session. Initially a mouse click monitor was installed on both computers to try and log the total number of flips made from each side of the display. It was the idea to use the click information and translate that directly into how many times that side had performed the flip option on a window. But this automatic way of finding the number of flips on each side was not as useful as first thought it would be. One of the reasons was the people clicked the mouse seemingly random without flipping the display, and in the secondary part of the test the participants had the option to not only flip but also enlarge and decrease the windows, and lastly it would not yield whether a click was performed from egoistic or friendly reasons. Thus the automatic data gathering was scrapped halfway into the testing period, and instead data contained in the spreadsheets was constructed by observing the raw video footage and making notes of the observations, and as such could be prone to some uncertainty, such as missing to note a mirror reading, or the intent of one of the participants.

5.1.4 IMPLICATIONS

The general remarks heard after each testing session was the phrase; “what is this good for?” and when and where could this ever be usefulness.

And as such it is still too early to really tell where this medium would be the most effective. But the reality is that it is possible to display content in this way, so in time it should find its merits.

And as some of the test participants said it could probably already be used for games such as chess or checkers, but then they changed their minds, as it would not be possible to display a three dimensional representation of the game environment. As it would not be possible to see who were play one and two were on screen because of optical properties, and traditionally player one is at the bottom. Also it was stated that the chess pieces could not be illustrated on such a screen. But the participants were still thinking of the screen as having to display three dimensional contents. And so on the last day of testing, thoughts were put to the test to ease the authors’ curiosity.

The following three games were put on the screen out of the box, with no tampering. The games used were; Chess¹, Connect 4², and Tic-Tac-Toe³. All known flash game. As seen in Figure 15 below.

These games work as they are not dependent on either a circular motion or have other horizontal restrictions. As long as the participants do not have to talk about which side they are making a move towards the games should work. Although the screen could still make use of some of the improvements stated previously like dividing it in two through the middle such as to allow for scoreboards or information fields that could be displayed normal for each side of the screen while at the same time be color coded to easily distinguish which side to look at.

¹ Chess game: http://www8.agame.com/mirror/flash/f/flash_chess.swf

² Connect 4 game: <http://www.owensworld.com/flashgames/files/connect4.swf>

³ Tic-Tac-Toe game: <http://www.goriya.com/flash/games/tictactoe1.swf>



Figure 15: Two dimensional games running on a DSi

So it would be an idea to run a test to find out which kinds of games would be plausible to use in conjunction with a dual sided display. I propose that the general restriction that games cannot have a game condition of a full circular motion in games, running either right or left. A game like backgammon has a half a circular motion but when playing the analog version of backgammon, player one has a circular motion of having to get his pieces clockwise home, and player two has to get his pieces counter clockwise. Because of this a game like backgammon would also work on a screen like this.

Games are interesting but testing people with a more interactive screen where they might be expected to draw images, from either instructions on cue cards, or an image of what they should draw.

5.2 RECOMMENDATIONS

In relation to further work conducted with base in this thesis, a few pointers will be given, to ease future implementations.

Use a neutral mouse pointer, and not the normal arrow pointer, if a pointer system is used, as the normal pointer gave an initial feeling of being on the wrong side of the screen for some people.

If a pointer system is to be used, it should be a true multipoint system instead of using a hack like was done in this test.

The best way of interaction would be either touch based, or near gesture, with a highlight of the position which was pointed towards.

If content is non-flip able and information is given to the user, a standard should be decided upon where the screen is split through the middle into two information areas, such that text for each user is always given to either his left or right side, just as long as this is done consistently for both sides.

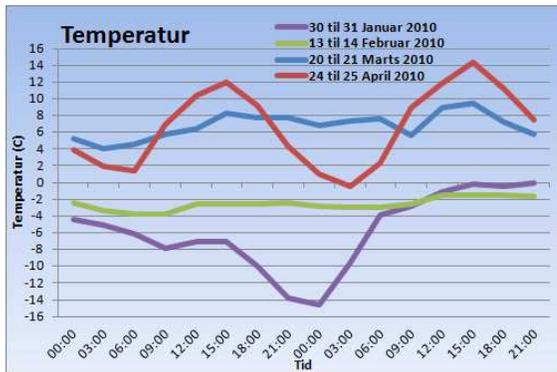
Also content should be color coded such that mirrored contents always displays in a different color then content not mirrored. This should make it easier to quickly see what part of the screen is currently mirrored to the observer.

If a mouse system is used in conjunction with buttons that can flip the display, these buttons would need to be centered, such that they did not flip with the display.

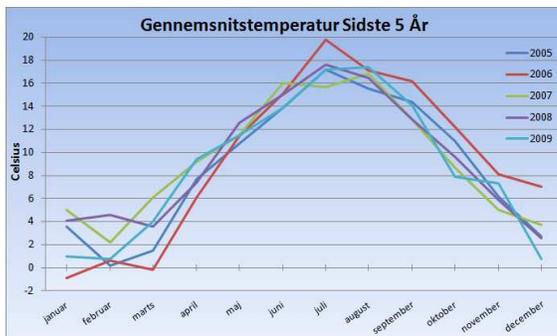
6 WORKS CITED

1. **Bahr, David Sebastian and Jensen, Bo Lind.** *The challenges of dual-sided interface design.* Aalborg : Aalborg University, 2009. Initial Master.
2. *Frostwall: a dual-sided situated display for informal collaboration in the corridor.* **Paay, Jeni, et al., et al.** Melbourne, Australia : ACM, 2009. OZCHI. pp. 369-372.
3. *Consigalo: multi-user face-to-face interaction on immaterial displays.* **Olwal, Alex, et al., et al.** Cancun, Mexico : ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering) , 2008. Proceedings of the 2nd international conference on INtelligent TEchnologies for interactive enterTAINment. p. Article No.: 8 .
4. **University, Cornell.** Glossary of Library Terms. [Online]
<http://copia.library.cornell.edu/newhelp/glossary.html>.
5. **Cryer, A B.** <http://www.cryer.co.uk>. [Online]
http://www.cryer.co.uk/glossary/s/spatial_data.htm.
6. **Misc.** Types_of_charts (wiki). [Online] http://en.wikipedia.org/wiki/Chart#Types_of_charts.
7. *A review of mobile hci.* **Kjeldskov, Jesper and Graham, Connor .** s.l. : Springer-Verlag Berlin Heidelberg, 2003. Mobile HCI. pp. 317-335.
8. *A Review of Computer Aided Software Engineering Research Methods.* **Wynekoop, Judy L and Conger, Sue A.** Copenhagen, Denmark : s.n., 1990. IFIP TC8 WG 8.2 Working Conference on The Information Systems Research Arena of The 90's. pp. 129-154.
9. **Rubin, Feffrey and Chisnell, Dana.** *Handbook of Usability Testing, How to Plan, Design, and Conduct Effective Tests.* SE. Indianapolis : Wiley Publishing, Inc, 2008.
10. **Kold, Daniel John and Petersen, Michael Henning Juul .** Exploring Interpersonal Interaction Through the Design, Evaluation, and Enhancement of a Mobile Game. *Exploring Interpersonal Interaction.* 2009, p. 42.
11. *An Explorative Analysis of User Evaluation Studies.* **Ellis, Geoffrey and Dix, Alan.** Venice, Italy : ACM, 2006. pp. 1-7.

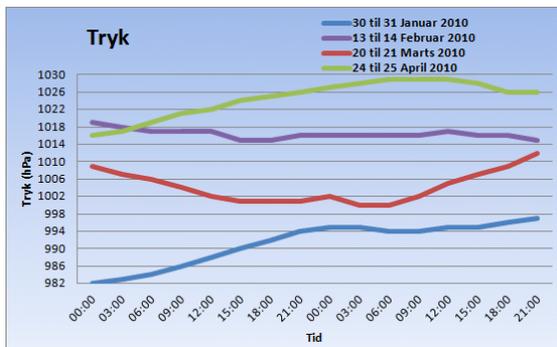
7 APPENDIX I: QUESTIONS AND GRAPHS



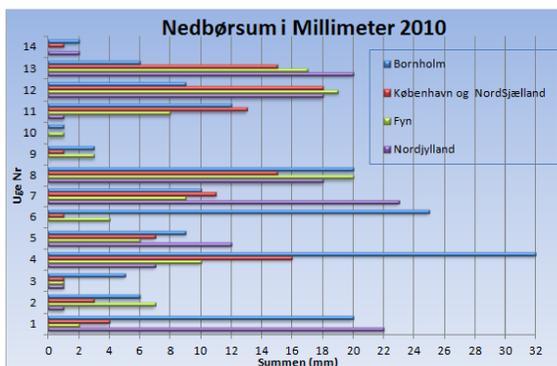
A1-1 (Læs Højt) I fællesskab skal i blive enige om; Den <u>højeste temperatur</u> blandt alle målinger. (I må meget gerne tænke højt).	A1-2 (Læs Højt) I fællesskab skal i blive enige om; Hvad <u>temperaturen</u> blev målt til klokken <u>09:00</u> den <u>30 januar</u> og den <u>14. februar</u> kl. 09:00. (I må meget gerne tænke højt).
A1-3 (Læs Højt) I fællesskab skal i blive enige om; Hvilken <u>tidsperiode</u> , der havde den længst varende " <u>nedgangs</u> " <u>tendens</u> i temperatur (fald over den længste periode). (I må meget gerne tænke højt).	A1-4 (Læs Højt) I fællesskab skal i blive enige om; Hvilke <u>tidsperioder</u> , der har de <u>længst og kortest</u> varende " <u>opgangs</u> " <u>tendenser</u> i temperatur. (stigning over den længste/korteste periode). (I må meget gerne tænke højt).



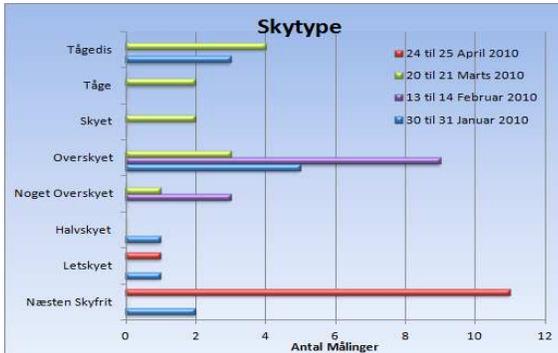
B1-1 (Læs IKKE Højt, men du må gerne tænke Højt) Du skal <u>forklare</u> den information <u>grafen</u> repræsenterer, <u>så din modpart</u> forstår den. (Evt: titel, akser, data) (Du må gerne sige hvad du har tænkt dig at gøre)
B1-2 (Læs IKKE Højt, men du må gerne tænke Højt) Du skal for modparten <u>angive</u> hvad <u>temperaturen</u> (ca.) var i <u>december 2006</u> . (Du må gerne sige hvad du har tænkt dig at gøre)
B1-3 (Læs IKKE Højt, men du må gerne tænke Højt) Du skal for "alle" målingerne, <u>angive</u> i <u>hvilken side</u> af grafen disse var <u>mest svingende</u> (største udslag). (Du må gerne sige hvad du har tænkt dig at gøre)



C1-1 (Læs IKKE Højt, men du må gerne tænke Højt) Du skal <u>forklare</u> den information <u>grafen</u> repræsenterer, <u>så din modpart</u> forstår den. (evt: titel, akser, data) (du må gerne sige hvad du har tænkt dig at gøre)
C1-2 (Læs IKKE Højt, men du må gerne tænke Højt) Du skal <u>angive</u> for modparten hvad trykket var kl. <u>00:00</u> den <u>20 marts</u> og igen den <u>21 marts</u> . (Du må gerne sige hvad du har tænkt dig at gøre)
C1-3 (Læs IKKE Højt, men du må gerne tænke Højt) Du skal for alle målinger <u>angive</u> hvor det <u>laveste og højeste tryk</u> blev målt. (Du må gerne sige hvad du har tænkt dig at gøre)



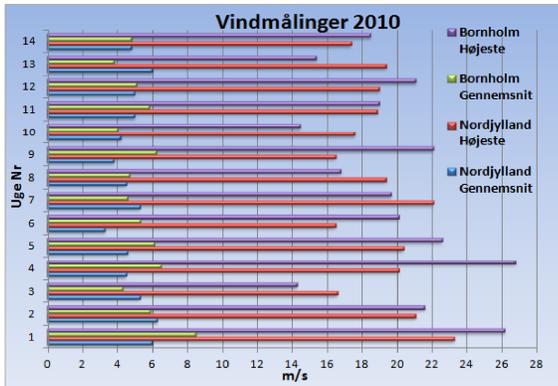
A2-1 (Læs Højt) I fællesskab skal i blive enige om; Hvor mange <u>millimeter nedbør</u> Fyn fik i <u>uge 8</u> .	A2-2 (Læs Højt) I fællesskab skal i blive enige om; Den eller De <u>længste perioder</u> hvor regnmængden var <u>aftagende</u> for henholdsvis <u>Bornholm</u> , og <u>København</u> .
A2-3 (Læs Højt) I fællesskab skal i blive enige om; Den eller De <u>længste perioder</u> hvor regnmængden var <u>stigende</u> i <u>Nordjylland</u> .	A2-4 (Læs Højt) I fællesskab skal i blive enige om; <u>Mængden</u> (summen) af <u>nedbør</u> "Bornholm" fik fra <u>uge 7 og 4 uger frem</u> . (Til og med den 4. uge.)



B2-1 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal forklar den information grafen repræsenterer, så din modpart forstår den.
(Evt: titel, akser, data)
(Du må gerne sige hvad du har tænkt dig at gøre)

B2-2 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal angive for modparten, hvordan vejret var størstedelen af dagene i "Februar" og "April".

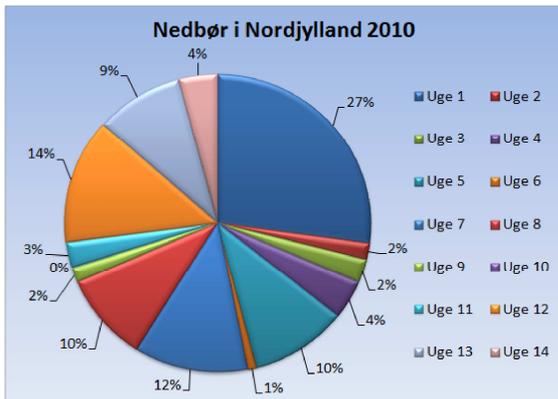
B2-3 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal blandt alle dagene angive antallet af målinger der blevforetaget af "Tågedis" og "Næsten Skyfrit".



C2-1 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal forklare den information grafen repræsenterer, så din modpart forstår den.
(Evt: titel, akser, data)
(Du må gerne sige hvad du har tænkt dig at gøre)

C2-2 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal for modparten angive, i hvilke uge "Nordjylland" havde den højeste vindstyrke.

C2-3 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal for modparten angive, i hvilke tidsperioder den gennemsnitlige vindstyrke på "Bornholm" var aftagende.

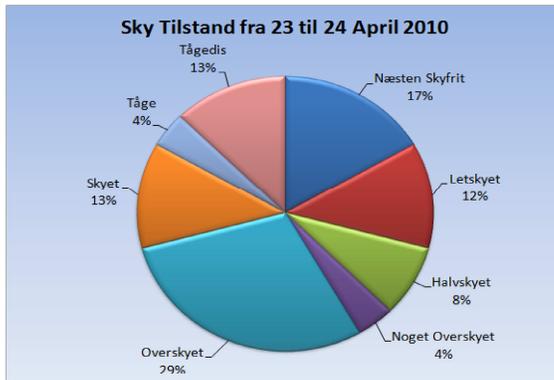


A3-1 (Læs Højt)
I fællesskab skal i blive enige om; Hvilken uge der havde den næsthøjeste procentdel af nedbør.

A3-2 (Læs Højt) I fællesskab skal i blive enige om; Hvor på grafen "uge 2" er afbilledet.

A3-3 (Læs Højt) I fællesskab skal i blive enige om; Hvilke uger det regnede mest og dermed tilsammen stod for 73% af nedbøren målt. (største værdier summeret op)

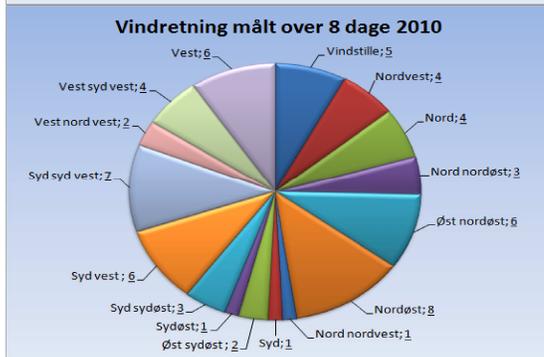
A3-4 (Læs Højt) I fællesskab skal i blive enige om; Hvilken uge der var helt uden nedbør.



B3-1 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal forklare den information grafen repræsenterer, så din modpart forstår den.
(Evt: titel, data)
(Du må gerne sige hvad du har tænkt dig at gøre)

B3-2 (Læs IKKE Højt, men du må gerne tænke Højt)
Angiv for modparten i hvilken retning de 4 målinger "Tågedis", "Letskyet", "Skyet" og "Noget overskyet" befinder sig på grafen.

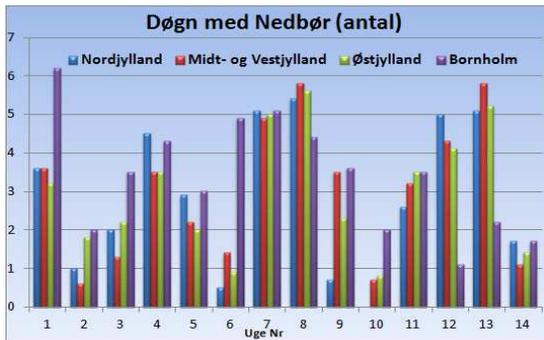
B3-3 (Læs IKKE Højt, men du må gerne tænke Højt)
Angiv for modparten hvor på grafen det er indikeret at det var "Næsten Skyfrit" og "Overskyet", samt hvor mange % de hver udgjorde.



C3-1 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal forklare den information grafen repræsenterer, så din modpart forstår den.
(Evt: titel, data)
(Du må gerne sige hvad du har tænkt dig at gøre)

C3-2 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal for din modpart fra toppen af grafen angive de 4 fortløbende målinger, og efterfølgende igen fra bunden (startende med "syd").

C3-3 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal for din modpart angive hvor på grafen det er indikeret, at det blæste fra "syd syd vest", "nord nordvest" og "nord nordøst".



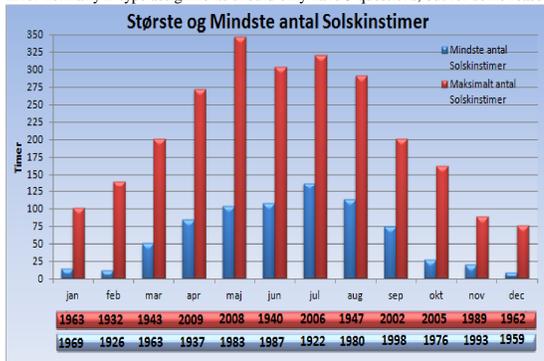
A4-1 (Læs Højt) I fællesskab skal i blive enige om:
I hvilken uge der i "Nordjylland" var flest dage med nedbør.

A4-2 (Læs Højt) I fællesskab skal i blive enige om:
Hvor på grafen nedbørs tendensen var stigende i "Østjylland".

A4-3 (Læs Højt)
I fællesskab skal i blive enige om;
I hvilke uger og regioner, der blev målt de 10 mindste mængder af nedbør.

A4-4 (Læs Højt) I fællesskab skal i blive enige om;
Hvor på grafen nedbørs tendensen var faldende i "Midt – og Vestjylland".

Error normally B type assignments should only have 3 questions, but for some reason this one slipped though.

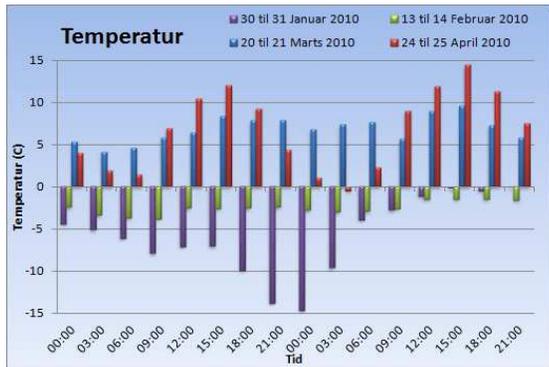


B4-1 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal forklar den information grafen repræsenterer, så din modpart forstår den.
(Evt: titel, data) (Du må gerne sige hvad du har tænkt dig at gøre)

B4-2 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal for din modpart angive hvor på grafen den eller de største antal solskinstimer er repræsenteret, og efterfølgende mindste antal timer.

B4-3 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal angive for din modpart, hvad det 6. mindste antal solskinstimer (Ca.) blev målt til, i hvilket år de blev målt, og hvor på grafen de er repræsenteret.

B4-4 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal angive for din modpart, hvad de 3 største (maksimale) antal solskinstimer (Ca.) blev målt til, samt i hvilke år og hvor på grafen de er repræsenteret.



C4-1 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal forklare den information grafen repræsenterer, så din modpart forstår den.
(Evt: titel, data)
(Du må gerne sige hvad du har tænkt dig at gøre)

C4-2 (Læs IKKE Højt, men du må gerne tænke Højt)
Du skal angive for din modpart hvad temperaturen var den 30. januar kl. 12:00, og ligeledes den 31. januar kl. 12:00.

C4-3 (Læs IKKE Højt, men du må gerne tænke Højt)
Angiv for din modpart, hvilken tidsperiode, der for "marts" måned, havde den længst varende stigning i temperatur.

<p>A5-1 (Læs Højt) I fællesskab skal i blive enige om; I hvilke <u>måned(er)</u> der blev registreret <u>over 150 timer</u> solskinstimer i Jylland i 2009.</p>	<p>A5-2 (Læs Højt) I fællesskab skal i blive enige om; Hvad <u>temperaturen</u> var i <u>størstedelen af dagene</u>, fra den 24. til 25. april.</p>	<p>A5-3 (Læs Højt) I fællesskab skal i blive enige om; <u>Hvor mange gange</u> det <u>næsthøjeste tryk</u> blev <u>målt</u> mellem den 30. og 31. januar.</p>
<p>A6-1 (Læs Højt) I fællesskab skal i blive enige om; I hvilke <u>måneder</u> der blev registreret <u>under 75</u> solskinstimer i Jylland i 2009.</p>	<p>A6-2 (Læs Højt) I fællesskab skal i blive enige om; <u>Hvor mange gange</u> den <u>laveste og næst laveste</u> temperatur blev <u>målt</u> mellem den 24. og 25. april.</p>	<p>A6-3 (Læs Højt) I fællesskab skal i blive enige om; <u>Hvor mange gange</u> det <u>mindste tryk</u> blev <u>målt</u> den 30. og 31. januar.</p>
<p>A7-1 (Læs Højt) I fællesskab skal i blive enige om; I <u>hvilket halvår</u> der blev registreret <u>flest solskinstimer</u> i Jylland i 2009.</p>	<p>A7-2 (Læs Højt) I fællesskab skal i blive enige om; Hvilke <u>temperatur intervaller</u>, der er <u>målt lige mange</u> af mellem den 24. og 25. april.</p>	<p>A7-3 (Læs Højt) I fællesskab skal i blive enige om; Det var mest <u>høje</u> eller <u>lave</u> tryk <u>målinger</u>, der blev foretaget fra den 30 til 31. januar.</p>

8 APPENDIX II: CLEANED AFTERTALK STATEMENTS

After the testing period was done an informal interview period of varying length was conducted with each test pair, this was done gain further insight into how the participants perceived the interaction, and to gather their overall thoughts on the screen, and its use.

Here are some of the statements people said:

In relation to the test itself and assignments

- It was boring
- It was fun to try
- There were many charts to look at.
- Did not understand some of the questions
- Would be just as smart to stand next to each other instead of sitting across
- This on one of the things that cannot be done with a normal display
- Would be more fun if it was possible to move the windows
- Would be exiting if one should be working on lots of diagrams and creating relations of one to many such as UML.

In relation to flipping and mirroring

- It was a easier to read from behind then having to flip it back and forth
- I could not read mirrored text at all
- It is easier when it is not reversed
- It is easier to read it in its original state, but you get use to read mirrored information
- The moment it starts to flip, you can lose focus

In relation to direction

- As soon as something is happening on the X-Axis you have to think real hard about it
- Vertical representations is easier than horizontal
- As soon as you have to agree on clockwise and counterclockwise it becomes even harder
- We are all brought up to read charts and letters a specific way

In relation to letters and numbers

- Letters and number are readable but longer combination become troublesome
- There was no way that I could read that it said “(antal)” It was just gibberish.
- Text is very hard, well you can read it once you get used to it, but you need to use extra energy on it, which might as well have been used to solve the problem instead.
- The single digits on the side was not as hard to read, as the number combination
- Using a thick font makes it almost unreadable
- The numbers 5 and 2 are hard to distinguish

On control and the mouse

- The one who presents, has the control of the mouse
- I had no need for the mouse, so no need to take it away from him
- A bit put off that the mouse pointer looked the same after the content was flipped.
- It became tedious to share the mouse
- Did not know when the other person was using the mouse
- I experienced that I stopped using the mouse as my partner had just been using it
- Would probably be much more accessible with touch.

In relations to the charts

- The Line chart could be miss interpreted as having rising tendencies when In fact they were falling
- Line charts harder to read as there were no guide lines to the points as opposed in a column chart.
- Circle diagram had the problem that the text is reversed, and it is a bit hard to tell where it starts”
- Column was easy to read
- I preferred the bar charts as it did not matter if they were facing left or right, the smallest number was always at the bottom

For improvements

- [If] it would be combined with some touch interface it could become fun
- True multipoint functionality (More cursors).
- Would be better with a touch based system
- Only flipping the text [labels], on a chart but leave origo in original place.
- No reason to flip the entire image only parts of it
- Assigning color information to mirrored components to was viewing
- If it was possible to point and give him the information, instead of having to find it again after a flip it would become more useful.

Application areas

- Used to brainstorm
- In a control room sharing information to the masses
- Military use for navigation charts
- Could be used in educational situations

Drawing and games

- Having multiple people draw on the screen at the same time, could let people terrorize others by painting black over a creative persons image.
- Drawing on the same model would be sweet.
- Chess checkers minesweeper, battleships

9 APPENDIX III: FLIP AND MIRROR FIGURES

