Technical support in collaborative decision making: an explorative study

Master thesis Mira Oberhagemann (s1087681)

University of Twente, August 2017

Supervisors:

Prof. Dr. F. van der Velde

Dr. X. Dai

Abstract

Background: Collaborative decision making is a complex group process. Supporting the structure of a collaborative decision making discussion and the communication during the discussion can lead to a more efficient discussion and better decision making. This support could be realized by technological support systems. However, the use of technology during a discussion could also have disadvantages, such as overburdening the cognitive capacities of the group members. Therefore the effects of implementing such a tool in a discussion should be investigated.

Goal: The goal of this work is to investigate the effects of a technical support tool for collaborative decision making. This research focuses mainly on possible benefits and disadvantages such a tool could have during a collaborative design discussion. Especially regarding the possible influence on the focus on the topic, the awareness of the communicational aspects used, the structure and flow of the discussion and the cognitive load.

Method: Four groups of four participants tested an app that was used as a prototype for a technical support tool during a collaborative design discussion. The experiment was set up in a two-by-two design, with each group having one discussion with and one discussion without the app. Both audio and video recordings were made of all discussions. After the sessions the participants were asked to answer questions about the aforementioned aspects of the discussions.

Results: The participants reported the discussion with the app to be more structured and that they were more conscious about the communicational aspects during those discussions. Those two effects seem to lead to a more efficient discussion and especially to better decisions. However, the flow of the discussions was disrupted by the app and participants reported a high cognitive load during the sessions with the app, describing the app as distracting and confusing. Finally, the setting of the experiment, the group dynamic and the topic of the discussion were found to have influence on the discussion and therefore possibly also on the use of the app.

Conclusion: The app does seem to have a beneficial effect on the discussion. However, regarding the negative aspects found, further research is recommended to see whether the positive effects would exceed the negative ones in an actual implementation.

Index

1. Introduction

In today's society, an increased use of intelligent systems (also called ambient intelligence) gets more common every day. Intelligent systems are systems that combine software with technology, such as sensors, to be integrated in fields as for example health care, daily life or business, where they enhance the environment (for examples see: Corchado et al, 2009; Cook et al., 2009). To be able to react in an intelligent way, a systems needs to have the ability to use reasoning, learn from its environment and to make decisions and choices about the actions it takes. (Negnevitsky, 2002).

Intelligent systems differ in the amount of intelligence they possess and therefore range from simple rule-based programs (such as sensors that enhance living environments with for example smart thermostats that control the temperature in your house, or apps that adjust the lights in an environment according to the user's presence) to more intelligent systems that can provide some sort of advanced reasoning (for example Amazon Alexa or IBM's Watson). Additionally, intelligent technological systems that assists the user's activities can be combined to make an enhanced and more intelligent system (Viterbo et al., 2010). Even though intelligent systems are already applied frequently, and research continually makes progress in developing those systems, it remains challenging to make a technology or system truly intelligent. Reasoning and decision making requires the ability of learning from situations and even though technology becomes increasingly advanced, additional research is still needed to be able to enhance artificial intelligence further (Bonstrom, 2016).

One of the research projects that aim to further develop intelligent systems is the "Living Smart Campus" program of the University of Twente, Enschede, the Netherlands. This program aims to enhance the university campus with technology, using the campus as a "living lab" to test possible solutions for complex social issues as well as enhancing cooperation and coordination on campus. It combines different research projects, such as autonomously detecting human activities in a space with Wi-Fi sensors or indoor navigation for visually impaired people. This project aims at giving researchers the possibility to develop and test smart technology in a realistic setting. (Startdocument Living Smart Campus, 2016)

As part of the "Living Smart Campus" program, this report explores if and how technology could enhance collaborative decision making processes in face-to-face group discussions. To enhance collaboration, group decision support systems (GDSS) are already known to integrate

different sources of information, providing relevant knowledge and structure decision making (for example to decide in which restaurant a group should go eat). If applied correctly and efficiently, decision support systems are able to increase the productivity, efficiency and effectiveness of decision making processes (Druzdzel & Flynn, 2002). However, current examples such as "LetsDoIt" do not include supporting decision making in a real time discussion but merely provide a voting system, including preferences of the people involved (Marques et al., 2016; Lesser et al., 2017) or support for decisions made by only one person (for example a manager of a company) (Druzdzel & Flynn, 2002). Previous research has shown that group decision support systems (GDSS) such as the "Software Aided Meeting Management" can be effective in e.g. facilitating group creativity and enhancing decision making (Nunamaker et al., 1987) by organizing the decision process and giving the member better insight in the procedure of the process (Poole et al., 1993). However, computerized GDSS usually are not applied in face-to-face, group discussions, but in interactive virtual groups, who work with messenger systems (Fulk & Steinfeld, 1990; Shim et al, 2002). The challenge of this report is, to explore the possibility of applying group decision support systems in a face-to-face decision making process with verbal communication only, which usually are the foundation for complex design problems (Conklin & Begeman, 1988).

1.1. Collaborative decision making

Collaborative decision making is a complex multi-agent socio-cognitive process. This means that a group of people tries to reach a consensus on a common decision by combining individual beliefs, desires, goals, intentions, and preferences with those of the other individuals involved in an interactive process (Panzarasa et al, 2002; Owen, 2015). Collaborative decision making implies either democratic decision making, where all group members are equally empowered to make contributions, or consensus decision making, where a leader shares a problem with a group and they reach a decision together (Lunenburg, 2011). In those processes, the group discusses about the reasons that lead to a design decision, the justifications, other alternatives that have been considered by the group and the evaluation of possible tradeoffs. Basically, it includes the whole argumentation process of the group that led to their decision (Lee, 1997).

The ideal outcome of a group decision process is a well thought through decision that mirrors ideas of the whole group. Hereby every individual should feel included and should feel that the

decision is (partly) his or her own (Owen, 2015; Lunenburg, 2011). Benefits of such a collaborative decision are, that the participants share their individual expertise about the different aspects that have to be discussed, which can enrich the final decision compared to a decision of a single person (Owen, 2015; Lunenburg, 2011)

Furthermore, it supports collaboration and therefore can strengthen teamwork by collaborative project management (Lee, 1997). This is the result of each individual participating in making the decision, resulting in an explicit agreement to implement the collaborative choices as a total of all individuals' participation (Owen, 2015).

A collaborative decision making process for a design decision requires the participants to discuss and to justify their arguments, to consider alternatives and tradeoffs and to ultimately include the whole argumentation that led to the decision (Lee, 1997). Therefore, it requires that each individual respects the other participants as member of the group. This means that they have to be accepted intentional agents and their internal states such as intentions, thoughts and emotions have to be acknowledged (Balzarotti et al., 2014). To accomplish that, communication is essential for collaborative decision making (Panzarasa et al., 2002).

1.2. Communication in collaborative decision making

In a decision making process, every aspect that is mentioned by a group member can be used as a part of the final design decision, as long as it is properly and reasonably presented. It is therefore required, that the communication, and therefore the presentation of different arguments by different group members, has a good structure (Lee, 1997). Good communication in collaborative decision making can avoid conflicts and establishes effective relations between group members, motivating individuals to get even more involved in the collaboration process. (Panzarasa et al., 2002).

To be able to give a decision making process a good structure, different decision layers have to be identified. In a study by Owen (2015) about decision making, he states that alternatives, information and values are the determining decision layers. Lee (1997) goes even further and divides the communication in a design decision making process into five decision layers: issue, argument, alternative, evaluation and criteria. To work with those five decision layers in a structured collaborative design decision making process, developing communicative

agreements between the participants is crucial to achieve a common goal (Balzarotti et al., 2014). First of all, the first of the five layers; defining the issue to assure that the main topic is clear to every participant. Identifying the issue first is the most important step in the decision making process. Without a defined frame of the issue, that is accepted by all participants, there could be the risk of discussions about different issues. This could lead to confusion and a decision that is not accepted by all of the individuals because they feel that the wrong problem is being addressed (Owen, 2015). To support the focus of the discussion on the defined issue, the participants should also be aware of the meta level of the discussion, so, aware of the fact that they are not talking about the defined issue anymore but that they have gone off subject. This awareness allows the group to keep the focus and stay within the defined frame. (Conklin & Begeman, 1988). In the frame of this research, this raises the question if technical support in a decision making discussion could influence and improve this focus on the topic at hand and prevent the discussion from going off subject.

The second step in a decision making process is to hear propositions, arguments and corresponding counter-arguments from all participants (Lee, 1997; Conklin & Begeman, 1988). Propositions are responses to the defined issue and need argumentation for or against them to resolve the issue (Conklin & Begeman, 1988).

A possible problem that could arise in that argumentation process is that people can have two kinds of thinking. The first kind is fast thinking (Kahnemann, 2011), which includes having an opinion about how the world works based on feelings. These thoughts come fast, have no reasoning and are described as “our sense of how the world works” (Kahnemann, 2011). The other kind is slow thinking, which includes the step by step reasoning to construct a well though through argument based on facts and actual knowledge. Slow thinking represents more than just a feeling about the issue at hand (Kahnemann, 2011). Important for collaborative decision making is that people use slow thinking to make an argument. Additionally, it is important for the other participants to experience those arguments as “slow-thinking” arguments and not just based on a feeling (Owen, 2015). In other words, the arguments need to have a clear, understandable link to the propositions and the underlying issue to be truly accepted by the group (Conklin & Begemann, 1988). To assure this link, it is required that the participants are aware of giving and receiving an argument and take enough time for their argumentation during the communication. As a result, propositions, arguments and alternatives that are well thought through and presented in a good argumentative structure, have the benefit of having a broader range and more diverse alternatives in a collaborative decision making process than they would

have in a single person decision (Owen, 2015; Lunenburg, 2011). The evaluation of the alternatives and possible arguments has to be understood by every participant, such that the costs and benefits are clear and agreed on by every participant, to make sure it results in a decision supported by the whole group (Owen, 2015).

In the last step of the decision making process, a decision is made. Crucial to reaching consensus about a design problem, is that it should be clear to every participant that a final decision is made, so that it can be guaranteed that all arguments and counter-arguments are taken into account (Owen, 2015).

To achieve that all those steps previously mentioned are implemented well in the discussion, it is required that all participants agree on the communicational structure that is used. This means for example that if the speaker thinks he gives an argument, the rest of the group has to perceive the given statement as an argument to communicate effectively (Johnson & Johnson, 2014). If the communication is well structured, the final decision will be a product of the collaboration of all arguments and alternatives of each participant combined, making the decision accepted by everyone and therefore more easily implemented. However, structuring communication is a process that people normally are unaware of and that happens without giving a thought to it (Langer et al., 1978), which leads to the question if a support tool could raise awareness about those communicational aspects and support the communicational structure by doing so.

1.3. Cognitive load

As already mentioned, this research aims to investigate the influence of a technical support tool on a collaborative decision making discussion. To do so, an app is used as a prototype of a technical support tool. A study by Lee (1997) shows that support tools for design rationales can improve dependency management, collaboration, reuse, maintenance, learning and documentation if they are representing design rationale systems. However, in collaborative decision making, the participants are overloaded with information and have different attitudes towards that information. For a technical support tool (such as the app used in this experiment) to be able to improve the design rationale and the design decision in an efficient way, it must supply the conceptual and structural elements of the processes that are needed to guide the participants in a design discussion to make a decision (Antunes et al., 2013). As mentioned earlier, the first step to a good discussion is to identify a common frame to be able to constrain

the areas that will be discussed in the decision making process. The topic of the discussion must therefore be identified and defined by the support tool, in order to serve as a well understood common base for the discussion. Additionally, the app as a support tool should include possibilities to define possible arguments and alternatives made during the discussion and define the boundaries of the decision that must be made (Owen, 2015).

The app used in this research is implemented as a technical support tool to let the user clearly identify a topic-frame about the pending issue, and gives the user the possibility to identify a frame of the communicational structure defined by Lee (1997) during the discussion. To assure the structured communication that is necessary to get to an aggregated decision, the app presents several communicational aspects for the user to choose, to make the user recognize the underlying structure that is active at that time and the issue that is talked about. Thereby it aims to enhance the focus on the issue that is discussed at that moment and on the communicational aspects used.

However, implementing such an app as a prototype of a technical support tool in a collaborative decision making discussion could also have disadvantages that should be considered. Possible problems that could arise with this form of documentation and support of decision making is that the interaction with the app during an ongoing discussion could break the natural flow of the discussion by overburdening the naturally limited verbal and visual cognitive capacities of the group members (Mayer & Moreno, 2003). Moreover, it could constrain creative ideas that seem to be outside the defined frame but in reality, are not (Lee, 1997). Research has shown, that group design support systems seem to make some procedures in the discussion making process more problematic regarding the cognitive load by adding the system to the discussion as a secondary task. This results in a more time-consuming discussion, because the group members do not only have to deal with the discussion but also with the task of using the technology (Watson et al., 1988). This results in less communication and some other effects which are less likely to occur in verbal-only communications, such as an inhibition in generating more ideas. Switching from a group design support system to person-to-person communication makes it difficult for group members to divide their cognitive capacities and use the technological support and the communication to its full potential (Poole et al., 1993). This is in line with the cognitive resource theory, which states, that there can be competition between the cognitive capacities that are used to process visual stimuli (such as the app or any other design support system) and audio stimuli (such as verbal communication) (Oviatt et al., 2004). Altogether, the use of a design support tool can require multitasking and cause disruption

in the flow of the activity and a possible cognitive overload that should be minimized as much as possible to make the use of the tool as efficiently as possible (Oviatt et al., 2004).

This research aims to minimize possible cognitive effort required by the support system by using a prototype that aims to improve the structure of the discussion and allows verbal communication only, thereby trying to minimize possible distractions. According to the informational load hypothesis, this minimization of distraction should be possible, because the use of an app that makes the user more aware of the communicational structure should require a minimal cognitive effort. According to that theory, the semantic information about the communicational structure should already be activated in the discussion, and only needs to be referred to by using the app (Oviatt et al., 2004). Therefore, the focus should lie on the discussion itself and the supporting functions of the app should stay in the background of the discussion. This is important, because a low cognitive load required by the support system would make the process of using the app and learning how to structure the communication easier and more efficient (Oviatt et al., 2004). The question that arises in this context is, whether using the app has an influence on the cognitive load during the discussion and if it disturbs or improves the flow of the discussion.

2. Research questions

Based on the discussed literature, six research questions were formulated regarding the use of technical support in collaborative decision making:

1. How does the usage of technical support in a collaborative decision making discussion influence the participants' focus on the topic at hand?
2. What influence has the use of technical support on the awareness about communicational aspects of a collaborative decision making discussion?
3. What influence has the use of technical support on the communicational structure of a collaborative decision making discussion?
4. What influence has the use of technical support on the cognitive load during a collaborative decision making discussion?
5. What influence has the use of technical support on the flow of the collaborative decision making discussion?

Regarding that this research is of an explorative nature, to find out what basic benefits and constraints of technical support are, the sixth research question is:

6. What other possible effects occur by using technical support in a collaborative design decision discussion which are not taken into account, based on the literature research so far?

3. Considerations for the design of the experiment

To be able to answer the research questions, an experiment is designed with a number of groups testing an app as a prototype of a support tool in a collaborative decision making discussion. Several requirements have to be taken into account for the design of this experiment.

First each group has to do two sessions, one with the app, the other one without the app, to make sure that possible effects that are found are not just because of the diversity of the groups.

Second, there has to be at least one group that starts with the app in the first session and works without the app in the second session. And at least one group that start without the app in the first session and then works with the app in the second session. These conditions are necessary to be able to rule out effects of familiarity that can occur in the second session. Familiarity means here that the group members do not know each other and are not familiar with the setting of the experiment in the first session, but are more familiar with each other and with the setting in the second session.

Third, there have to be two different design topics to discuss due to practical reasons. It is not motivating to discuss a design question two times. Unfortunately, this leads to the effect that possible differences in outcome of the two sessions could also be due to the different topics. To take that into account, there have to be at least two groups for each condition (starting with the app or starting without the app), one that starts with the first topic and one that starts with the second topic.

To take all the possible influences mentioned above into account, the experiment has to be set up with a two-by-two design with at least four groups, which will be further explained in the next section.

4. Method

4.1. Design

As mentioned before, this study has a two-by-two design which means, that there are four different possible combinations of the condition "with app", the condition "without app", the topic "website" and the topic "bicycle parking" as shown in table 1.

Table 1

Overview of the classification of groups in design conditions

Group number	*Participant number*	*Session 1*	*Session 2*
1 (Pilot test)	1, 2, 3, 4	Without app – bicycle	With app – website
2	5, 6, 7, 8	With app - bicycle	Without app - website
3	9, 10, 11, 12	Without app - bicycle	With app- website
4	13, 14, 15, 16	With app - website	Without app - bicycle
5	17,18,19,20	Without app- website	With app - bicycle

The two discussed topics, design questions about a bicycle parking system at the university and design questions about a website for the students and employees of the university (for more information see appendix 2) were created for this experiment based on four different factors. First, they had to be about something out of the daily life of the students, such that the students could develop the feeling to design something meaningful to them. Second, the issues were designed as problems that actually exists on the university (not necessarily problems that actually have to be addressed, but nevertheless realistic). Third, the issues were chosen as if they could actually be part of the living smart campus project. Fourth, all three questions for both issues were created regarding a practical part, a question about possible implementation in the daily life of the students on the campus and a maintenance part, to represent different important questions in a design project.

The students were not asked to take costs into account, because it was anticipated that their experience with realistic cost estimations is low. Moreover, it was anticipated that this could limit the ideas that are brought forward, when the participants are not able to estimate if the idea is realistic or affordable. However, the participants were free to integrate estimated costs in their argumentation if they wanted to. (The instructions for each condition, each issue and the informed-consent form can be found in appendix 6 and 8).

4.2. Materials

For the setting of this research, different materials were used. The data is collected in a record-and-replay approach where the decision making process is recorded synchronously via an audio and video recording system that captures the unfolding discussion. Additionally, in one half of the discussions, an asynchronous recording of the decision making process takes place by using the app. For the video recordings of the session, two video-cameras were used. Those cameras were set-up to both sides of the group and from a high angle. This enables the recording of all gestures and facial expressions and to have an accurate picture of the turn taking during the discussion. Two cameras were enough to get a sufficient view of all the participants faces. Furthermore, for the audio recording, a digital voice recorder was used to get an audio data of the session. The voice recorder was also used to record the interviews at the end of each session. Further voice recording was done by Apple iPads.

There were four iPads (one for each participant) which were equipped with the apps MM Record and MM Report. The iPads were also equipped with a (microphone-only) headset. On all iPads, the app MM Record was used in combination with the headset to make an individual voice recording of the participant that was using that iPad. Also, in the sessions with app, the app MM Record was used to register the use of the programmed buttons. The app MM Report was used only for storing all the information that is recorded by MM Record.

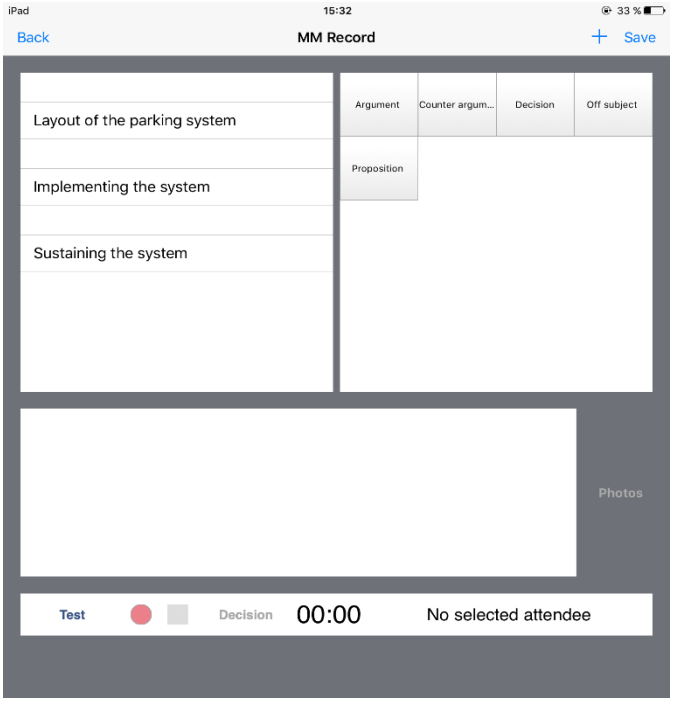


Figure 1. Screenshot of the app MM Record as used in the condition with the topic "bicycle parking"

Two audio recording methods were chosen, because the individual recordings are easier to collect and analyze in combination with the use of the app (especially in the sessions with the app) and the voice recorder is then used to have a clear recording of the whole discussion. Also, the two recordings served as a fail-safe option. The apps MM Record and MM report are freely available for IOS devices in the Apple app store. They were originally designed and programmed by Tech-cico at the Université de Technologie de Troyes in France and were originally used as a meeting annotation and report tool (Xinghang, Nada, & Guillaume, 2015).

Additionally, combined with all the objective data that was acquired by the recordings of each session, this study also provides qualitative data acquired by a semi-structured interview, which is split in three different parts. The three parts are based on the condition of the sessions that the participant had before the interview and consist of interview 1, which is about decision making with the app, interview 2 which is about decision making without the app, and finally the last part, interview 3, which is about a comparison between those two processes. The questions in the interviews are based on the research questions and hypotheses. The interview starts with questions that are open and broad, to capture as many thoughts of the participants as possible and is then complemented with more precise, but still open follow-up questions. The follow-up questions are constructed in a way that they lead in the direction of the research questions, to make sure the information needed to answer them is collected. This process gives the advantage of having the data needed for the research. Simultaneously, it gives the participants the ability to say everything they want to say, possibly leading to potential important data containing aspects that are new to the research and not considered in the research questions. Additionally, the participants had to fill in a questionnaire at the end of each session (see appendix 9 and 10 for the interview schema and the questionnaire). The qualitative data gives the possibility to explore the participants' perception of the app and its use. It helps to get rich and explorative data about the app, which might give more insight in the usability of the app. As mentioned before, the interviews also were recorded by a voice recorder to give the interviewer the opportunity to concentrate on conducting the interview, without the need to make notes and to have a complete recording of all answers for the analysis. This research will mainly focus on the analysis of the semi-structured interviews. However, the results of the quantitative analysis of the recorded sessions and the analysis of the questionnaire, that are both conducted by other researchers will be taken into account in the discussion of this thesis.

For each session of the experiment, instruction material was needed. This includes instruction material for each session and each condition for the instructor, instruction material for each

session and each condition for the participants and an informed-consent form. The instructions for the instructor are about the necessary information that the participants need to have to start the experiment. (for the complete instructor instructions see appendix 7). The instruction manual for the participants included information about the condition in which they were participating (with or without the app) and the topic they had to discuss.

4.3. Participants

To answer the research question, twenty participants in groups of four took part in a collaborative decision making process, answered a questionnaire and were interviewed individually. They were separated in five groups of four, the first group was used for a pilot test and the other four groups for the actual experiment. The participants were recruited via the participant-system of the University of Twente, SONA. The participants had to sign up for the research, with the condition that they had to be available on both scheduled timeslots. The participants could earn three SONA -credits for their participation (which they need in order to complete their study program) and had the chance of winning a coupon worth 20 euros (five coupons to give away), both to evoke motivation for participation. In order to win the coupons, the participants had to write down an email address at the end of the first session, which was used for a random lottery drawing at the end of the experiment.

All recruited participants were psychology students of the University of Twente, between 18 and 22 years old, with an average age of 20 years (m = 20, sd = 1,01) and they took part in the experiment as part of their course program. Also, it was convenient to have students as participants, because they are used to discussions in groups (with group members they don't know) due to multiple group-projects that they have to do during their study program. Additionally, the students have no further design background. No other sample criteria were used, because design decisions are commonly made in different situations by different groups.

4.4. Pilot test

The pilot test was conducted with the first group of participants to test all the technical equipment and the instruction materials for the participants, as well as the instruction materials for the session-instructor. The pilot test showed, that the two cameras were sufficient to capture

all participants well. Also, some minor technical issues could be solved. For the instruction materials, the pilot test showed that especially the instruction for the with-app condition was not specific enough. Moreover, there was a tendency that the participants did not read the instruction very carefully. This lead to improved instruction materials for the participants, and additional instruction material for the session-instructor (see appendix 7).

4.5. Procedure

As mentioned above, the experiment was divided in two parts for each group. The two different sessions of each group were at two consecutive days and took about 90 minutes each, including the interview and the questionnaire. Before every session, the session-instructor had to fill in form 1 (appendix 5). In the first session, the instructor welcomed the participants and set up all the equipment, which gave the participants time to read their instructions (appendix 6). After the participants finished reading, the instructor asked if there are any questions and answered them if necessary. Also, the instructor proceeded to ask questions to test the understanding of the participants of the setting and gave further instructions (especially in the with-app condition) (appendix 7). Then, the participants proceeded to read and sign the informed consent (appendix 8). After every participant signed the informed consent, the instructor again asked if there are any questions and answered them if necessary. Next, the instructor asked every participant to put on the headset and started all the recordings, starting with the recordings of the cameras, then the voice recorder and then the recordings of the app. After all the recordings were started, the instructor clapped his hands, to set a common starting point on all recordings and as a sign for the participants to start their discussion.

The discussion took 30 minutes, in which the participants had to discuss the given issue and, dependent on the experimental condition of the session, use the app or not. During the discussions where the app is used, when the instructor noticed that participants seem to forget using the app, he or she reminded them to do so, by tapping them on the shoulder, or reminding the whole group verbally. Also, the instructor indicated when there were 10 minutes remaining, and when the time is up. During the discussion with the app, the participants were asked to use the app by selecting the discussed issue on the left hand on the screen and select a communicational aspects on the right hand of the screen (see figure 1). The communicational aspects had to be chosen based on the contributions of the participants. Therefore, if any of the

participants gave a proposition, argument or any of the other communicational aspects that were indicated by the buttons of the app, the participants were ask to press the buttons accordingly.

After the discussion, first all the app-recordings were stopped and saved in MM Report, then all other recordings were stopped and the participants could take off their headsets. Afterwards, the participants again had the option to ask questions. When all questions are answered, the instructor asked the participants one by one in a random order to participate in the interview, while the others waited outside the room. The selected participant filled out the questionnaire (appendix 9), the instructor again explained that the interviews would be recorded and then started the recording followed by the actual interview (appendix 10). After the interview, the recoding was stopped and the participant again had the option to ask questions. After each session, the data of the session was transferred to a computer. Every audio recording of individual participants was given a participant-number (1-20) (appendix 1) to ensure anonymity. In the second session of the experiment, the same procedure was used with materials (instructions, interview and questionnaire) for the complementary condition, except that the participants did not have to sign the informed-consent again.

5. Results

5.1. Analysis

The data analysis of the interviews is done according to Baarda (2013). The analysis is based on the concept of "grounded theory", which means that the data is analyzed in an iterative process, to extract information on which a new theory could be founded.

The analysis required a transcription of all the interviews, which was done in a word processing application. The following step of the analysis was to identify all parts of the interviews that could be relevant for the analysis and to put them in a spreadsheet file for further processing. A spreadsheet was chosen because of the possibility to put the three interview-parts of one participant next to each other. This enabled a better comparison of the statements about the different conditions. Moreover, the tags could be processed in columns next to the interview text and there are unlimited possibilities to add extra tags (columns). After all interviews were processed in the spreadsheet files, which means removing irrelevant text parts and combining the three interview-parts of every participant in one sheet, the relevant information was labeled. The first step in this process, is to label the data regarding the main topics (*sensitizing concepts*) that were found relevant in the background research for this study, namely: "discussion", "communicational aspects", "decisions" and "cognitive load". Also the concepts "setting", "app", "group" and "topic" have been added to find possible influences on the found effects of the app. Those concepts were then used as a first classification of the data and had to be refined in further analysis. It should be noted that in this step of the analysis, the two raters are still open to additional possible concepts that were not defined in the background research, such that no important information will be omitted. After the first coding of the interviews with the sensitizing concepts, all parts that were labeled with one of the concepts were read again and then labeled with more specific theme-codes that give an overview on what the participants say about the sensitizing concepts (for the sensitizing concept "discussion" for example: "communication", "structure", "depth". For a full list of codes see appendix 13). The final step of the analysis was to read all the data again and label them a third time. This time the data is labeled with the variation-codes positive, negative or neutral, which makes the coding even more specific and gives an indication about the statement that already is labeled with a theme-code.

To verify and validate the labels that were found, an inter-rater reliability was calculated based on the labeling of a second rater. To do so, the second rater independently labeled 25% of the interviews. That is, the interviews of one randomly chosen participant of every group. Based on those labels Cohen's kappa was calculated:

Table 2

Cohen's Kappa

Interview	***Code***	***Calculation kappa***
P7	Sensitizing concepts	$\kappa = \frac{0{,}97 - 0{,}23}{1 - 0{,}23} = \frac{0{,}74}{0{,}77} = 0{,}96$
	Theme codes	$\kappa = \frac{0{,}95 - 0{,}12}{1 - 0{,}12} = \frac{0{,}74}{0{,}79} = 0{,}94$
	Variation codes	$\kappa = \frac{0{,}95 - 0{,}37}{1 - 0{,}37} = \frac{0{,}58}{0{,}63} = 0{,}92$
P12	Sensitizing concepts	$\kappa = \frac{0{,}96 - 0{,}17}{1 - 0{,}17} = \frac{0{,}79}{0{,}83} = 0{,}95$
	Theme codes	$\kappa = \frac{0{,}96 - 0{,}08}{1 - 0{,}08} = \frac{0{,}88}{0{,}92} = 0{,}96$
	Variation codes	$\kappa = \frac{0{,}92 - 0{,}38}{1 - 0{,}38} = \frac{0{,}54}{0{,}62} = 0{,}87$
P14	Sensitizing concepts	$\kappa = \frac{0{,}9 - 0{,}21}{1 - 0{,}21} = \frac{0{,}69}{0{,}79} = 0{,}87$
	Theme codes	$\kappa = \frac{0{,}9 - 0{,}09}{1 - 0{,}09} = \frac{0{,}81}{0{,}91} = 0{,}89$
	Variation codes	$\kappa = \frac{0{,}9 - 0{,}37}{1 - 0{,}37} = \frac{0{,}53}{0{,}63} = 0{,}84$
P19	Sensitizing concepts	$\kappa = \frac{0{,}9 - 0{,}23}{1 - 0{,}23} = \frac{0{,}67}{0{,}77} = 0{,}87$
	Theme codes	$\kappa = \frac{0{,}9 - 0{,}08}{1 - 0{,}08} = \frac{0{,}82}{0{,}92} = 0{,}89$
	Variation codes	$\kappa = \frac{0{,}9 - 0{,}38}{1 - 0{,}38} = \frac{0{,}52}{0{,}62} = 0{,}84$

The Cohen's kappa that is calculated for the four interviews is between 0.84 and 0.96 which represents an almost perfect agreement of the raters (Landis & Koch, 1977) For the extended version of the calculation see appendix 11.

Additional to the qualitative analysis, a statistical analysis of the number of codes found was conducted. Descriptive statistics were used to test the normality of the data. Additionally, regarding the small sample size of the data, a non-parametric test was used to test for differences

between the conditions. For the comparison of the positive and negative statements the Mann-Whitney-U test was conducted. Furthermore, to test the differences between the ratings for the two different topics the Wilcoxon signed rank sum test was used.

5.2. Results of the qualitative analysis

In this section an overview of the results of the interviews is shown. The results are presented for each interview part. They are divided in results for each session of each group, and the interview part were the participants compared the two sessions. For and overview over those results see the tables in appendix 12. Group one is the group for the pilot test, for more information about that group see section 2.4. In the following paragraphs the results of the sessions will be subdivided in the results about the discussion, the communicational aspects and the decision, the cognitive load and finally a part with the result of additional aspects that were found.

5.2.1. Group 2

5.2.1.1. First session

Discussion

In this session, the group discussed the topic "bicycle parking" whilst using the app. In the general discussion almost all aspects were perceived negatively by all participants. Participant 5 (P5) and P8 said about the discussion that they perceived it as superficial. All four participants also had a negative opinion on the flow of the discussion, the focus of the discussion and especially the structure of the discussion. For example, P8 said that she "*got lost in the discussion*" and that the discussion was "*not really well organized*". Additionally, P6 said that the group lost focus on the discussed issues and that the use of the app disrupted the flow of the discussion. However, three of the four participants also reported the general focus on the issues as good. P6 and P7 said that their discussion was first structured by those three issues, but that they started to jump between the issues during the discussion.

The communication in the discussion was perceived as good and understandable by P5 and P8, but P6 and P8 also mentioned that is was sometimes unstructured in the way that "*some people were faster or slower than others*".

Communicational aspects and decisions

The interview showed that the opinions about the communicational aspects in this session were mostly negative. P6 did not like their arguments and three of the four participants thought that the use of the communicational aspect was unstructured. Furthermore, the participants did not agree on whether the focus on the communicational aspects was positive or negative. P6 and P8 found it helpful to be focused on the communicational aspects that are used, P5 was not focused on the communicational aspects and P7 found it to be confusing to have to think about them, and to focus on which communicational aspect are used during the discussion.

Despite the negative perception of the discussion and the communicational aspects of this session, the decisions in general were perceived as positive by the whole group, even though P8 was not sure about what the content of the decision really was, and P5 thought that the decisions could have been discussed more.

Cognitive load

The general negative opinion about the discussion also mirrored in the negative judgment of the cognitive load. All group members perceived the secondary task of using the app as distracting from the discussion and P8 also thought the app "*would inhibit the discussion a bit*". P6 even directly called the general influence of the app negative and mentioned that she forgot to switch between the issues during the discussion. On the other hand P6 also said that she could imagine the benefits of the app for the analysis of a discussion, because of the ability to see what issue is being discussed. Furthermore, P8 thought that the app could be really useful if the discussion would generally be a bit more structured.

Other aspects

Further apparent effects are that P6 and P7 perceived the dynamic of the group as negative as well as the setting because it was "*awkward*" to talk in a group that you do not know, resulting in an unnatural discussion.

Three of the four participants found the topic they had to discuss to be difficult because they did not know much about it. Furthermore, P7 found it especially difficult, because as psychology students they did not know any technical aspects about the topic that they discussed.

5.2.1.2. Second session

Discussion

For the second session, the second group had to discuss the topic "website" without using the app. The discussion in this session was perceived as more positive than in the first session. P5 and P6 described the general communication in the discussion as positive and P5 and P7 liked the flow of the discussion. The discussion was perceived as focused on the topic by three of the four participants, even though P6 was unsure about how good that focus was. Moreover, P8 thought that it wasn't helpful to the focus of discussion that they "*didn't really pay attention to what [they] were doing*" regarding the communicational structure. The structure of the discussion is, just as in the first session, perceived negative by all participants and described as overlapping and unstructured.

Communicational aspects and decisions

Without the use of the app, only P6 and P8 commented on the communicational aspects during the interview. P6 did not like that there were almost no counter-arguments, but thought that the arguments and propositions were okay, whereas P8 stressed not being aware of the communicational structure without using the app. She felt that this could make coming to a decision more difficult, "*because then you don't really know what the counter-arguments and what the arguments are, so you don't really know what the best option is*."

However, the decisions made in this discussion are perceived as fitting by P6 and as "*okay*" by P7. Moreover, P8 said that she had thought that they "*thought about a lot of things even in depth now*" compared to the first session. P6 and P7 said that especially the decisions about the functions of the website made sense.

Cognitive load

Only P8 stated in the interview that the overall focus on the discussion was better "*because you didn't had another task to do, so you weren't distracted*". The other participants did not comment on that.

Other aspects

The setting was again reported as perceived negative in general by P7, who described the discussion as forced. The overall group dynamic on the other hand, had no apparent negative

influence with P6 and P8 thinking that they "*agreed on almost everything*", which P8 found to be positive and P6 found to be a negative influence on the discussion.

There were only a few comments from P5 and P6 on the topic in this session. P5 liked the topic better than talking about bicycles. P6 mentioned that it led to a discussion which was partly off subject.

5.2.1.3. Comparison

Discussion

P5 and P6 found the general discussions to be similar. Additionally, P5 thought that the communication in the discussion without app was better because they could talk to each other more without being disrupted. Furthermore, the discussions with app had more depth according to P6 and a better structure because of the app according to P7 and P8. However, P8 thought that the discussion without app is more thought through because they could discuss more. Also, three of four group members thought that the app disrupted the flow of the discussion and half of the group mentioned that it was easier to focus on the discussion when they did not have to use the app.

Communicational aspects and decisions

In the comparison of the communicational aspects, a difference between the sessions was reported, but almost all comments made about that difference are made only by P6. P6 said that she thought that the app was distracting. In hindsight however, she found that being conscious about being off subject and the other communicational aspects, helped to structure the discussion and gave a better argumentation with good arguments and counter-arguments. P8 agreed that the app helped structure the communication by making the group members aware of the communicational aspects.

The decisions were described as good and not different by P6 and P7, with the addition that P6 was under the impression that the decisions for the session with app were a bit more thought through because of the app. P5 was thinking the opposite: that the decision without app were better, because they could discuss about them more without the app. P8 also believed that the decisions were easier for the topic "website".

Cognitive load

Despite positive comments about the influence of the app on the communicational aspects, P8 thought that one loses time in the discussion while thinking about what those aspects are. P7 thought that one loses the focus on the discussion when using the app. Moreover, she did not really know when to push which button, which made the use of the app distracting. P5 had a similar opinion, stating that discussing without the app was more fluent than with the app.

Other aspects

It was again reported by one participant that the communication in the discussion felt forced (P7) as well as that the limited time frame had a negative influence on the discussion (P8). Additionally, the topic "website" was perceived as easier by P5 and P6. No further statements were made about influences of group, setting or topic of the discussion.

5.2.2. Group 3

5.2.2.1. First session

Discussion

The first session of this group was without the app and about the topic "bicycle parking". Half of the group reported the general discussion as "*quite okay*" and "*quite elaborate*". Despite that, the opinions about the focus during the discussion were split between positive and negative, ranging from "*being pretty focused*" to "*not [drifting] off too often*" to "*somehow [getting…] lost sometimes*". Also, the general structure of the discussion was perceived negative by three of the four participants and was described as "*lacking*" and "*unstructured*".

Communicational aspects and decision

Regarding the communicational aspects, participant P10 was under the impression that they tried to come up with good arguments and that she thought that the group always tried to have the aspects in mind during the discussion. Furthermore P9 and P12 described the use of the aspects as sometimes unstructured and P11 criticized the lack of counter-arguments.

The general decisions that were made in this discussion were perceived as positive by the whole group and described as "*pretty accurate*" or "*pretty fine*" but P11 also thought that they "*need a lot more discussion*".

Cognitive load

P12 decided to write things down during the discussion and reported this secondary task as beneficial for the structure of the discussion.

Other aspects

P12 reported the setting of the experiment to be "*intimidating*" because of the recoding, and P10 and P12 found the topic both uninteresting and difficult because they did not know a lot about it. The dynamic of the group was perceived equally negative and positive. P12 and P9 found everybody to be a bit shy, and P11 believed that the participants needed to get used to each other first. On the other hand P10 mentioned that "*it was nice that always someone felt the need to break the pauses and [to come] up with new ideas*".

5.2.2.2. Second session

Discussion

In the second session this group had to discuss about the topic "website" whilst using the app. Almost all aspects of the discussion were rated as positive. Especially the communication during the discussion, the focus and the structure of the discussion. The communication was described as "*quite good*" and better than in the first discussion. Furthermore, the participants said that they had a good focus and payed more attention to the discussion because of the app. Moreover, the group thought that the discussion was well structured and half of the group said that this also was a result of using the app.

Communicational aspects

The positive perception of the discussion can also be seen in the reports of the participants about the communicational aspects. Here again, almost all aspects were rated positive by the whole group, especially being conscious about the communicational aspects, counter-arguments, the focus, and the structure of the communicational aspects. For example, P11 said that by asking to classify the communicational aspects, the app made them more aware of those aspects and the structure of the discussion, which really improved the structure. P12 agreed that the app made her more aware of the communicational aspects with as a result that she'd "*care more about what people actually said, instead of just [agreeing]*" without getting "*carried away*".

The resulting decisions were generally rated as positive, even though all participants mentioned some negative aspects of the decisions. P11 found the decision to be dependent on limited knowledge about the topic, P9 and P10 found them to be dependent on the issue, with good decisions for the first two issues they discussed and no agreement about the third issue, and lastly P10 and P12 were not totally satisfied with the content of the decisions because of different personal opinions.

Cognitive load

Three of the four group members thought that the app was a bit distracting because you could miss information while you were using it (P9), which made the discussion more difficult (P12) and that it was "*annoying to get both things done at once*" (P10), but P12 also said that the app was less distracting than she expected it to be.

Other aspects

The topic "website" is perceived as interesting by P10 and P12, whereas the group dynamic in this session is described as negative by three of the four participants, because two of the participants disagreed and it was "*hard [for the other two] to say something in between*". P12 especially stressed the bad contribution of one of the other participants, saying that this participant kept quiet for too long, while disagreeing with the decisions in the end.

5.2.2.3. Comparison

Discussion

In the comparing part of the interviews, the flow, the depth, the focus and especially the structure of the discussion was perceived as better in the discussion with the app. P10 thought for example, that the app "*shifted the focus more on the actual topic*" and P11 reckoned that it gave them more time to think about the topic in depth. P9 too believed that the flow was better in the second discussion, because the participants knew each other by then, but that the app disrupted that flow partly.

The discussion without the app on the other hand, was also generally perceived as positive by three of the four group members, even though P11 felt that it went off topic.

Communicational aspects and decisions

Regarding the communicational aspects, the participants almost solely talked about the those aspects in the interviews about the discussion with app. P9 and P11 for example, thought that they were more aware of the communicational aspects they used, which improved the structure of the discussion

Comparing the decisions of both discussions, both P11 and P10 reported to be more aware of and more satisfied with the decisions that were made in the session with app, because the app made her more aware of the decisions. However, P10 said this could partly be because of the topic as well.

Cognitive load

P11 reported that, because they had to focus on two things at once, the "*creative freedom*" during the discussion was inhibited. In contrast to that, P12 thought before the discussion that "*[she'd] be slightly distracted*" by the app, but say that "*it was fine*" and that "*there was no big distraction*"

Other aspects

P12 said that the group dynamic was different in both sessions, because they "*got to know each other better and [they] were more used to the whole setting*" in the second session. She also believed that there was more agreement in the first session. Moreover, P9 felt that the participants were "*less shy*" in the second session.

Regarding the differences in the topics, P9 and P10 reported the topic "website" to be easier, because they felt more involved with it.

5.2.3. Group 4

5.2.3.1. First session

Discussion

The first session of the fourth group was with the app and the topic "website". The general discussion in this session was rated as positive, especially the communication and the focus. Regarding the communication, three of the four participants said that it went well, and all participants agreed that they were focused on the subject. However, P13 mentioned that the app

disrupted that focus a bit, whereas P16 stated that her focus was improved by the app. The flow of the discussion on the other hand was rated negative by half of the group. P16 thought that this was because of three different factors, namely the structure of their communication, the difference in English skills in the group and because the app inhibited him in contributing to the discussion. P15, on the other hand thought it to be mainly because of the negative group dynamic and the different English skills. For the structure of the discussion, both negative and positive statements were made. On the one hand the overall discussion was described as very well structured by the whole group, on the other hand it was mentioned by three of the four group members, that their structure was dependent on the issue they were talking about. For example P15 and P16 thought that the structure of the discussion about the implementation of the website was not good.

Communicational aspects and decisions

Regarding the communicational aspects, all participants reported it as positive to be conscious about them during the discussion. P13 found the app making her more aware of the intentions of the other members of the group. P14 agreed with that, stating that using the app made her more aware of what the others were trying to express. P15 added that "*clicking the button […] implied that you had had to follow up on what they were saying and make that you had to listen and make an active decision about what the content of what they were saying was*". Also the participants liked the propositions that were made, how they structured the communicational aspects and how focused they were on the aspects because of the app. However, two of the four participants felt that they did not bring in enough counter-arguments.

Three of four participants stated that they were satisfied with the decisions that were made. P14 stressed that the app was really helpful in making it clear when a decision was made, because you had to consciously click on a button.

Cognitive load

Regarding the cognitive load, the opinion of the group was divided. Participants 13 and 16 perceived the cognitive load due to the secondary task as negative. Especially participant 16 seemed to be bothered by the use of the app. He said that he forgot to use the app when others were talking and found the app to be inhibiting for the discussion.

P14 and P15 on the other hand did not comment on the cognitive load but described the use and the general influence of the app mostly as positive. P15 said that she liked how it "*scheduled*

the speaking portion of everyone quite well" and that the app "*did keep [her] involved*" in the discussion. P15 also added that there should be more or other buttons to give more options in choosing communicational elements such as "*building up on that*".

Other aspects

P14 thought that they were "*very polite about agreeing and disagreeing with each other*" and thought that everyone in the group was "*comfortable sharing what they thought, because everyone was respected*" and P13 agreed with that, in contrast to the other two participants who found the dynamic in the group to be "too friendly" and the English skills too different to have a good discussion.

Regarding the topic, P14 liked to discuss about it, whereas P15 and 16 found it to be difficult to talk about the website, because they never thought about it before and did not have many ideas. P15 additionally thought that 30 minutes was not enough time to discuss about the topic, and P16 would have liked a time restriction on the three issues.

5.2.3.2. Second session

Discussion

The second session of this group was without the use of the app and about the topic "bicycle parking". The general discussion was described as positive by two of the participants, and P16 stressed that he thinks the discussion had a better flow than their first discussion. However, the content, depth and focus were perceived negative. P16 especially disliked the content, because he thought they jumped between the ideas without talking about them in depth and P14 stressed that they focused randomly on those ideas without giving the discussion a clear focus or a "*red line*".

The opinion about the structure of the discussion divided the group in two, P13 and P15 thought that the discussion was well structured and P15 added that this was "*because they were trained to schedule it and to separate all different parts of the discussion*" in the session with the app. In contrast to that, P16 thought that they just "*hopped from one point to another without clearly making a decision*" and P14 found the discussion to be unstructured due to the topic being broad.

Communicational aspects and decisions

There were not many comments made on the communicational aspects. P14 said that she consciously tried to think about the aspects in contrast to P13, who did not thought about them at all. Furthermore P14 also thought that there weren't that focused on the aspects and went off topic sometimes. She thought structuring the communicational aspects more could have made the decisions more efficient. In contrast to that, P16 thought that it "*was a good flow of exchanging propositions, arguments and counter-arguments*".

The decisions generally were found to be good according to P14 and P15, but they "*need more discussion*" according to P14 and P16. P16 stated that he was not satisfied with the decisions because he personally did not like them and P13 even thought that they did not make clear decisions.

Cognitive load

P16 said that he liked that the discussion was not inhibited by having to use the app, whereas P15 said that the app still had a positive structuring influence on the discussion even though it was not used this time.

Other aspects

P16 felt that he had to go with the ideas of the rest of the group because he did not want to "*trigger a discussion*" and P15 found that "*some people didn't want to contribute as much*". Also P14 and P15 found the time limit of the sessions a negative factor; P15 thought this because she did not like the topic and she was looking at the time checking when it would be over and, in contrast to that, P14 felt that they needed more time to come to better decisions. All four participants agreed on the topic "bicycle parking" being difficult to discuss, because it was too broad and not interesting nor relevant to them.

5.2.3.3. Comparison

Discussion

Comparing the two discussions, P14 found the discussion with app to be really good and the discussion without app also to be okay regarding the general discussion. P15 thought that both discussions went well because they had to use the app in the first session. Furthermore, P14 especially stressed the positive aspects of the discussion with the app and said that it made the

discussion more structured and better discussed in depth. Moreover, P14 mentioned that the app made everyone consciously let the others finish talking, which made the discussion more smooth compared to the discussion without the app. P13 and P16 had similar opinions as P14, namely that the discussion was more structure with the app. However, P16 found the discussion without the app to be less inhibited and P16 and P13 also thought that they could focus better on the discussion itself without the app.

Communicational aspects and decisions

Regarding the communicational aspects, P14 said that the app made them more aware about the communicational aspects. She thought this led to a better structure, and ultimately to better and "*a lot more focus on getting to a decision*". In contrast to that, she described the structure of the communicational aspects in the session without app as "*a little chaotic at times*". Also, P13 liked being aware of giving an argument or making a decision with the app. P16 found the structure to be better in the session without the app, which he thought was because the app in combination with focusing on the communicational aspects, inhibited the discussion, but also due to the topic.

P13 said that she "*wasn't really aware of when [they] made a decision and when [they] didn't*" in the session without app, therefore she found the decisions in the first session more clear. P14 augmented in a similar way, that the decisions in the session with app where a logic conclusion. However, the decisions in general were found to be (largely) dependent on the topic by three of the four participants.

Cognitive load

P16 and P13 mentioned that they were distracted by the app, and P16 specifically mentioned that he found it easier to discuss without it. P14 and P15 on the other hand, made no comments on the cognitive load, but described the general influence of the app as making the discussion smooth, by having to be more focused on what everyone is saying. P15 even said that the app positively influenced the second session because it trained them in thinking more structured.

Other aspects

P15 was under the impression that the group contributed less to the topic "bicycle parking", because it was less interesting, and P14 also mentioned that the topics were very different and that the topic "bicycle parking" was the more difficult one. P15 also described the topics as very different and not comparable. Regarding the setting, P14 mentioned that the time

restriction of 30 minutes was restricting in the second session. She said that this was because the discussion was less structured and therefore more time was needed to come to a decision.

5.2.4. Group 5

5.2.4.1. First session

Discussion

The fifth group started with the topic "website" and without using the app. P19 said that she liked the discussion in general and P20 described it as good. Three of the four participants described the focus on the discussion in the group generally as good.

The opinions on the structure of the discussion on the other hand, were divided; P17 found it to be unstructured and P18 described it as mixed up in the end but okay in general. However, P19 and P20 described it as okay and better towards the end.

Communicational aspects and decisions

P19 and P20 thought that they had good arguments and P19 also liked how they structured the communicational aspects. Additionally, P17 and P19 criticized the small number of counter-arguments.

Cognitive load

Due to the discussion being without the app, nothing was said about the use or influence of the app and the cognitive load.

Other aspects

Three of the four participants perceived it as positive that everybody contributed and agreed with each other. Also, P19 mentioned that he found the focus of the group on especially two of the three issues to be good and that they had a lot of information and inspiration about the topic.

5.2.4.2. Second session

Discussion

In this session the group worked with the app to discussion the topic "bicycle parking". The discussion was generally perceived as good by P19 and P20. Most notably, all participants were

positive regarding the structure and described the discussion as generally well structured. Moreover, P19 liked that everyone participated, and P20 was under the impression that everyone was agreeing with one another. P20 mentioned that she was so focused on the discussion, that she forgot to use the app. In contrast to that, P18 stated that she was focused on the discussion, but that the app broke that focus because she "*was a bit confused by the Ipad sometimes*".

Communicational aspects and decisions

All participants stated that they were more conscious about the communicational aspects because of the app, which they found to be supporting for their decisions. P20 for example found it more clear what they were saying, and P17 brought forward that the buttons are a reminder to structure the communicational aspects and to come to a decision. However, P19 still criticized that they had not many counter-arguments.

Three of the four participants stated that they made good decisions in this session. P18 did not comment on that.

Cognitive load

The cognitive load of the secondary task of using the app is perceived as negative by three of the four participants. They described it as confusing to use or distracting, and P20 sometimes just forgot to use the app which did not influence her focus on the discussion. Additionally, P17 and P20 thought that the app generally had a positive influence on the discussion and P17 said that you get used to it during the discussion and that it gets easier to divide the attention.

Other aspects

Three of the four participants described the overall group dynamic and contribution as positive. P19 said that they "*all said something and nobody was just sitting there saying: yeah it's okay*" and P20 felt that the group was thinking "*more in the same direction*". The setting and the topic did not seem to have any further influences on the discussion.

5.2.4.3. Comparison

Discussion

P19 found the flow in both discussions to be good, but the discussion without the app a bit more fluent, and P18 described the structure of both discussion to be similar. P18 and P20 stated that

they thought the flow of the discussion was better in the second session, because they knew each other better. Additionally, P20 thought they found more ways to look at the topic because of the app. P18 mentions that the discussion about the bicycle parking was more focused because the topic was less broad. She also mentioned that the depth of the discussion without app was positive. There were no negative remarks for both discussions.

Communicational aspects and decisions

Regarding the communicational aspects, P17 and P19 found the structure of the aspects more obvious with the app, which, according to them, made it easier to communicate. Furthermore P17 and P20 liked the structure of the aspects in the discussion to be guided and more structured by the app.

Three of the four participants found the decisions to be dependent on the topic. P18 and P20 found the decisions for the topic "bicycle parking" more superficial and the decisions for the topic "website" better thought through. However, they also mentioned that the app made them more conscious about the decisions.

Cognitive load

P17 found it difficult to use the app at first but she got used to it during the session. She also says that the app helps guiding the communication. Also, P20 mentioned that the discussion was improved by the use of the app.

Other aspects

Three of the four participants described the group dynamic as generally good and were more comfortable with each other in the second session. There were no further comments on the topics and the setting.

5.2.5. Results of the quantitative analysis

In this section the described results will be statistically summarized for each of the sensitizing concepts. For the complete tables of the descriptive statistics, the results of the Mann-Whitney U test and the tables on which this analysis is based see appendix 14, 15 and 16.

Discussion:

Descriptive statistics (appendix 15) showed that the participants rated both discussions as positive in general. However the discussion without app in general was rated slightly more positive than the discussion with app with an average of 3.50 positive ratings (*Mdn* = 3.0; *Range* = 2; *SD* = 1.000) and only one negative rating (*M* = 0.25; *Mdn* = 0; *Range* = 1; *SD* = .500) per group for the general discussion without app. In contrast to that, the discussion with app was rated with an average of 2.75 positive ratings (*Mdn* = 3.0; *Range* = 5; *SD* = 2.217) and 0.50 negative ratings (*Mdn* = 0.5; *Range* = 1; *SD* = .577) per group. However, the only significant effect about the rating of the general discussion was that the number of positive ratings for the discussion without app was significantly higher than the number of negative ratings. All other difference for the rating of the general discussion were not significant.

Table 3

Significant effects: Discussion

	Condition*	***Z***	***Asymp. Sig. (2-tailed)***
Communication	3	-2.191	.028
Flow	2	-2.124	.034
General	4	-2.428	.015
Structure	1	-2.191	.028
	4	-1.764	.078

**1 = comparison with app positive – without app positive; 2 = with app negative – without app negative; 3 = comparison with app positive – with app negative; 4 = comparison without app positive – without app negative*

Striking results for the discussion were found for the communication, the flow, the structure and the focus. The structure, the focus and the communication all were perceived better in the discussion with the app. The structure of the discussion was perceived significantly more positive for the discussion (p = .028, see table 3) with app with an average of 8.75 positive ratings (*Mdn* = 9.5; *Range* = 8; *SD* = 3.403) and 4.50 negative ratings (*Mdn* = 3.5; *Range* = 11; *SD* = 4.796) per group, whereas the structure of the discussion without app was rated as negative with an average of only 2.25 positive ratings (*Mdn* = 2; *Range* = 3; *SD* = 1.500) and an average of 5.50 negative ratings (*Mdn* = 5.5; *Range* = 5; *SD* = 2.380) per group. The focus on the discussion and the communication were rated positive for both sessions, with and without app. However, the sessions with app were rated more positive for both factors. The focus on the

discussion with app was rated with an average of 6.50 positive ratings (*Mdn* = 5.5; *Range* = 9; *SD* = 4.359) and an average of 3.75 negative ratings (*Mdn* = 2.5; *Range* = 8; *SD* = 3.594) per group, whereas the focus on the discussion without app was rated with an average of 3.75 positive ratings (*Mdn* = 3.0; *Range* = 5; *SD* = 2.217) and an average of 3.00 negative ratings (*Mdn* = 3.0; *Range* = 4; *SD* = 1.633) per group. None of the differences found for the focus on the discussion were significant.

The communication was rated significantly positive for the discussion with app ($p = .028$) with an average of 3.75 positive ratings (*Mdn* = 3.5; *Range* = 4; *SD* = 1.708) and an average of one negative rating (*Mdn* = 1.0; *Range* = 2; *SD* = .816) per group. Compared to that the communication in the discussion without app was rated less positive with an average of only 1.25 positive ratings (*Mdn* = 0.5; *Range* = 4; *SD* = 1.893) and an average of 0.5 negative ratings (*Mdn* = 0.5; *Range* = 1; *SD* = .577) per group.

In contrast to that, the flow of the discussion was rated significantly positive for the discussion without app (p = .034) with an average of 2.25 positive ratings (*Mdn* = 1.5; *Range* = 6; *SD* = 2.872) per group and only one negative statement (*M* = 0.25; M*dn* = 0; *Range* = 1; *SD* = .500). The flow of the discussion with app on the other hand was rated negative with an average of 3.25 negative ratings (*Mdn* = 3.0; *Range* = 5; *SD* = 2.630) and only 1.75 positive ratings (*Mdn* = 2.0; *Range* = 3; *SD* = 1.258) per group.

Communicational aspects and decision:

The first effect of the app on the communicational aspects and also the most distinctive effect is, that the participants mentioned to be significantly more conscious about the communicational aspects with the app (p = .019). That can be seen in the ratings about being conscious about the communicational aspects. They were rated significantly positive ($p = .017$) with an average of 8.50 positive ratings (*Mdn* = 10.0; *Range* = 8; *SD* = 3.786) and an average of only 0.50 negative ratings (*Mdn* = 0; *Range* = 2; *SD* = 1.000) for the discussion with app and an average of only 0.50 positive ratings (*Mdn* = 0.5; *Range* = 1; *SD* = .577) and an average of one negative rating (*Mdn* = 0.5; *Range* = 3; *SD* = 1.414) per group for the discussion without app. This consciousness about the communicational aspects is can also be found in the overall number of statements about the communicational aspects in general. For the discussions with the app, a total of 118 statements was made, which were mostly positive (positive statements: *n* = 93; *M* = 23.25; *Mdn* = 27.0; *Range* = 19; *SD* = 9.032; negative statements: *n* = 25; *M* = 6.25; *Mdn* = 5.5; *Range* = 10; *SD* = 4.193), whereas for the discussions without app, only 30

statements were made (positive statements: *n* = 8; *M* = 2.00; *Mdn* = 2.5; *Range* = 3; *SD* = 1.414; negative statements: *n* = 22; *M* = 5.50; *Mdn* = 5.5; *Range* = 7; *SD* = 3.109). Another effect that support those results is that the focus on the communicational aspects during the discussion also was perceived as slightly more positive in the discussion with app (positive statements: *n* = 13; *M* = 3.25; *Mdn* = 2.5; *Range* = 6; *SD* = 2.630; negative statements: *n* = 5; *M* = 1.25; *Mdn* = 1.0; *Range* = 3; *SD* = 1.500) compared to the discussion without app (positive statements: *n* = 0; negative statements: *n* = 2; *M* = 0.50; *Mdn* = 0.5; *Range* = 1; *SD* = .577).

Table 4

Significant effects: Communicational aspects

	Condition*	***Z***	***Asymp. Sig. (2-tailed)***
Conscious about them	1	-2.352	.019
	3	-2.381	.017
Counter-arguments	1	-2.000	.046
	4	-2.000	.046
Decisions	1	-1.984	.047
Focus	1	-2.460	.014
Off subject	1	-2.049	.040
Propositions	1	-1.984	.047

**1 = comparison with app positive – without app positive; 2 = with app negative – without app negative; 3 = comparison with app positive – with app negative; 4 = comparison without app positive – without app negative*

Furthermore, the structure of the communicational aspects and the decisions were rated higher in the discussions with app. The structure of the discussion was perceived positive in the discussion with app with an average of 3.50 positive statements (*Mdn* = 4.5; *Range* = 5; *SD* = 2.380) and an average of 1.25 negative statements (*Mdn* = 0.5; *Range* = 4; *SD* = 1.893) per group. Compared to that, the structure of the communicational aspects in the discussion without app was perceived negative with an average of 1.25 negative statements (*Mdn* = 1.5; *Range* = 2; *SD* = .957) and an average of only 0.75 positive statements (*Mdn* = 0.5; *Range* = 2; *SD* = .957) per group. However, in further analysis, none of those difference was found to be significant.

Regarding the communicational aspects, the decisions were perceived to be positive in the discussion with app with an average of three positive statements (*Mdn* = 2.5; *Range* = 7; *SD* =

2.944) and an average of only 0.50 negative statements (*Mdn* = 0.5; *Range* = 1; *SD* = .577). The decisions in the discussion without app were perceived to be negative, but only with an average of 0.50 negative statements per group (*Mdn* = 0; *Range* = 2; *SD* = 1.000). No positive statements were made about the decisions in the discussion without the app regarding the communicational aspects. The differences between the positive ratings of the decisions in the discussions with app and the rating of the decisions in the discussions without app were found to be significant (p = .047, see table 4).

The indication that is given about the decisions regarding the communicational aspects is supported by the results for the sensitizing concept "decisions". The participants reported the decisions in general to be significantly positive for the discussion with app (p = .019) and also positive, but not significantly, for the discussion without app. Table 5 shows that the decisions in general in the discussion with the app are rated (almost significantly) more positive than those in the discussion without app (positive with app: *M* = 5.00; *Mdn* = 5.0; *Range* = 2; *SD* = 1.155; positive without app: *M* = 3.25; *Mdn* = 3.0; *Range* = 3; *SD* = 1.258). Additionally there were less negative reports on average on the general decisions with the app (negative with app: *M* = 0.75; *Mdn* = 0.5; *Range* = 2; *SD* = .957; negative without app: *M* = 1.50; *Mdn* = 1.0; *Range* = 4; *SD* = 1.915).

Table 5

Significant effects: Decisions

	Condition*	***Z***	***Asymp. Sig. (2-tailed)***
General	1	-1.764	.078
	3	-2.352	.019

**1 = comparison with app positive – without app positive; 2 = with app negative – without app negative; 3 = comparison with app positive – with app negative; 4 = comparison without app positive – without app negative*

Also, the depth of the decisions in the discussion with app is perceived positive (positive statements: *M* = 1.00; *Mdn* = 1.0; *Range* = 2; *SD* = .816; negative statements: *M* = 0.50; *Mdn* = 0; *Range* = 2; *SD* = 1.000) in contrast to the depth of the discussions without app, which is perceived slightly negative (positive statements: *M* = 0.50; *Mdn* = 0; Rang*e* = 2; *SD* = 1.000; negative statements: *M* = 1.50; *Mdn* = 1.0; *Range* = 4; *SD* = 1.915), even though this difference is not found to be significant.

However, the content of the decisions is rated positive for the discussion without app with an average of 1.75 positive statements (*Mdn* = 1.5; *Range* = 4; *SD* = 1.708) and an average of only 0.50 negative statements (*Mdn* = 0; *Range* = 2; *SD* = 1.000) per group. The content of the decisions in the discussions with app on the other hand are perceived slightly negative with an average of one negative statement (*Mdn* = 1.0; *Range* = 2; *SD* = 1.155) and only 0.75 positive statements (*Mdn* = 0.5; *Range* = 2; *SD* = .957) per group.

Cognitive load:

Table 6 shows that the app as a secondary task was perceived as significantly negative by all groups (*M* = 7.75; *Mdn* = 6.0; *Range* = 7; *SD* = 3.500) with on average only one positive statement made per group (*Mdn* = 1.0; *Range* = 2 ; *SD* = .816). Also the participants reported it to perceive it as positive if they did not have to do a secondary task with an average of 2.50 positive statements per group (*Mdn* = 1.5; *Range* = 7; *SD* = 3.317), even though this reported difference was not significant.

Table 6

Comparison (Mann-Whitney U): positive ratings – negative ratings

Sensitizing concept	***Theme-code***	***Z***	***Asymp. Sig. (2-tailed)***
Cognitive load	*Secondary task*	-2.381	.017
App	*General influence*	-2.124	.034
Topic	*Content "bicycle parking"*	-1.703	.089

The general influence of the app on the other hand was mainly perceived as positive with an average of four positive statements (*Mdn* = 3.0; *Range* = 9; *SD* = 3.830) per group and an only one negative statement.

The participants reported positive as well as negative aspects about the use of the app with on average two positive statements (*Mdn* = 2.0; *Range* = 2; *SD* = .816) and 1.75 negative statements (*Mdn* = 2.0; *Range* = 1; *SD* = .500) made per group.

Other aspects:

The most apparent additional aspects that influenced the discussions was the topic; the topic "website" is rated better than the topic "bicycle". The topic "website" has a positive rating with 2.50 positive statements on average per group (*Mdn* = 2.5; *Range* = 3; *SD* = 1.732) and only

one negative statement on average per group (*Mdn* = 0.5; *Range* = 3; *SD* = 1.414). The topic "bike" on the other hand is perceived as mainly negative by the participants, with an average of 3.75 negative statements (*Mdn* = 4.0; *Range* = 7; *SD* = 2.872) per group and only one positive statement. However, the only significant difference for the topics that was found was that the topic "bicycle parking" is rated significantly more positive than negative as can be seen in table 6, all other effect were not significant.

Other influencing effects on the discussion were found to be aspects of the group and the setting of the experiment. The interviews showed that not the overall rating of the group dynamic or the contribution of the participants had an influence on the discussion, but more specific aspects mentioned by individual participants, such as for example the level of English skills. The setting of the experiment in general was reported as negative (negative statements: *M* = 1.50; *Mdn* = 0.5; *Range* = 5; *SD* = 2.380). Also the participants made three negative statements about being recorded (*M* = 0.75; *Mdn* = 0.5; *Range* = 2; *SD* = .957) and seven negative statements about having a limited time frame for the discussion (*M* = 2.00; *Mdn* = 1.5; *Range* = 5; *SD* = 2.160).

6. Additional results for the data from this study

Additional subjective measurements (Schoot-Uiterkamp, 2017)

Participants had to fill in a questionnaire after each session, answering questions about contributions, quality of decisions, quality of the discussion, effectiveness of the discussion, communication flow, structure, focus, clarity of content, depth, participation and collaboration.

The results of that questionnaire show that the "with app" condition was generally rated with higher scores compared to the session without app. They also indicated a (not significant) positive effect of the app on the focus on the topic at hand during the discussion compared to the discussion without app.

The two different discussed topics showed some influence on the discussion. For the discussion about the website, the discussion effectiveness and depth of the discussion was better, compared to the discussion about the bicycle parking, even though this effect is also not significant.. Also the clarity of communication flow was perceived significantly better in the discussion with the topic "website".

Comparable to the results of the interviews, the order of the discussions with and without app did not have any significant influence on the examined factors.

Both the condition ("with" or "without app") and the two different topics seem to have influence on focus, communication flow, depth, decisions, discussion effectiveness, structure and discussion quality. However, none of the effects were significant.

Additional objective measures

To analyze the data in an objective manner, a group of researchers conducted an analysis of the discussions based on the video files of this experiment. This analysis focused on turn-taking, number of words, cognitive enrichment and coherence of tagging as objective measurements. The results of the analysis are outlined further per measurement type.

1. Number of words and turn-taking (Warnke, 2017)

The changes in amount of words, turn-taking and equality of number of words and turn-taking of each participant were analyzed for each session. The app was considered to improve the

discussion when more words were used, less turns were taken and both the number of words and the turn-taking was more equally divided between participants

Comparing the conditions regarding the number of words, no significant increase was found between the “without app” condition and the “with app” condition, as expected by the researcher, but rather a small decrease in number of words for the condition “with app” for three of the four groups. The topic at hand and the order of sessions did not have and influence on the number of words.

The turn-taking in the sessions with the app was significantly decreased. Additionally, in the sessions without app, there were significantly more turn-takings in the discussions about the topic “website” than there were for the topic “bicycle parking”. This difference was not found for the sessions with the app. For the topic “website”, there were less turn-takings in the discussions with app than in the discussions without app. This difference was not found for the topic “bicycle parking” and there were also no differences found for turn-taking regarding the order of the sessions

Three of the four groups showed a lower standard distribution of number of words in the sessions with app, which indicates a higher equality of number of words per participant. Also, in the sessions were the group had to discuss with the app, the number of turn-takings was spread more equally. However, in every group, one member had a word count that was notably higher than that of the rest of the group’s participants.

2. Cognitive enrichment (Block, 2017)

Each time a participant adds a new concept (super-concept, sub concept or sister concept) to a discussion, this was counted to analyze the concept of cognitive enrichment.

The discussion is considered to be better if there are more cognitive enrichments given by the participants. This suggests the discussion to be more productive and having a broader collaborative perspective, which improves the depth of the discussion. Therefore, the researcher expected more cognitive enrichment in the discussions with the app compared to the discussion without it. Cognitive enrichments were counted per minute.

There was no significant difference found in number of cognitive enrichments between the sessions with and without app. The range of number of cognitive enrichments per minute was higher for the sessions with app and the mean also was slightly higher for the sessions with app, however, those results were both not significant.

3. Coherence of tagging (Versteegh, 2017)

To analyze the coherence of the tags the researcher identified the different communicational aspects (proposition, argument, counter-argument, decision and off subject) of each participants in each session for group 2 and group 5.

The number of communicational aspects found was lower in the discussions with app. Additionally, for both groups the overall number of propositions and arguments was higher than the number of the other communicational aspects in both sessions. Table 10 gives and overview over the results.

Table 7

Amount of communicational aspects per group per session

	Group 2 - session 1 with app – bicycle	***Group 2- session 2 without app - website***	***Group 5 - session 1 without app - website***	***Group 5 - session 2 with app - bicycle***
Proposition	77	58	143	49
Argument	72	89	61	31
Counter-argument	15	22	59	14
Decision	22	50	171	5
Off subject	6	3	57	8
Total	192	222	491	107

The results show that the use of the app had no influence on the number of propositions or on the number of times that were identified as off topic. On the other hand, less arguments, less counter-arguments and less decisions were made in the discussions with app compared to the discussions without app. However, this effect could also be caused by the topic. In general, more communicational aspects were counted for the sessions with app and with the topic "website" than for the sessions without app and about the topic "bicycle parking". This could be due to the discussed topic or due to the app having a positive influence on the structure of the discussion, making the discussion more efficient.

7. Answering the research questions

The goal of this research was to use an app-prototype of a technical support tool for collaborative decision making, to identify possible benefits and disadvantages of such a tool. The app was designed to represent elements of the content and communicational structure of a discussion and was tested in four groups in a two-by-two design. To get a good overview over the effect of the app, six research questions were identified, which are presented again and answered one by one in this section:

1. *How does the usage of technical support in a collaborative decision making discussion influence the participants' focus on the topic at hand?*

The app had a positive influence on the focus on the topic at hand in the discussion. However, this positive effect was not significant and a few negative aspects were mentioned about the influence of the app on the focus as well.

In general, the focus on the topic at hand was perceived better in the discussion with the app than in the discussion without the app. However, especially the groups that started with the discussion with the app perceived it as easier to focus on the discussion when the app is not used. Those participants were under the impression that the app disrupted the focus on the topic and on the discussion. Participants also said to forget the app if they had a good focus on the discussion, which would make the app useless. Two groups rated the focus on the discussion to be better because of the app. They thought that the app shifts the focus more on the topic and that it prevented the group from going off topic. Moreover, some individuals of the groups that reported the app to have a negative influence on the focus, also mentioned some positive influences of the app. One participant found the app to be improving the focus on the discussion, despite her group thinking otherwise. Additionally, both groups that started with the app, reported the discussion without app to be lacking a "*red line*" and that the group was not really paying attention to what they were doing.

2. *What influence has the use of technical support on the communicational structure of a collaborative decision making discussion?*

The app, as a prototype for a technical support tool, had a significant, positive influence on the structure of the discussion.

Three of the four groups reported the discussion with the app to be better structured than the discussion without the app. Only the last group did not report any differences between the two conditions. All discussions without app were described as unstructured or participants reported to be jumping back and forth between the issues. On the other hand, all sessions with the app were reported as structured, or at least better structured with respect to the discussions without app, regardless of the order of the sessions. Participants explicitly stated that they thought this was the effect of the app. P15 even reported the discussion without app in her second session to be better structured, because she felt trained by the app and kept that trained structure in her mind. This suggests that the app was indirectly helping to structure the discussion, even when it was not used, through a learning effect.

3. *What influence has the use of technical support on the awareness about communicational aspects of a collaborative decision making discussion?*

The app significantly improved the awareness of the communicational aspects, their structure and made the participants more conscious about them during the discussion, which resulted in a better argumentation and better decisions.

This positive effect of the app on the communicational aspects was the most apparent effect found. The statements that were made about the communicational aspects for the discussions without the app were that they contained good but unstructured propositions and arguments. Also they were reported to be lacking counter-arguments. However, not many statements for the communicational aspects were made for those discussions when compared to the discussions with app. This could indicate that the participants were not conscious about the communicational aspects without the app. A confirmation for that is to be found in the interviews about the sessions with the app and the comparisons of the two sessions: The participants explicitly mentioned to be aware of the communicational aspects and to consciously think about them in the session with the app. In the groups that started with the app, this effect was less apparent than in the groups that start without. However, they still reported to be more aware of the communicational aspects and they agreed that the structure of the communicational aspects is better with the app, than without. The participants reported that being more conscious about those aspects led to a better argumentation and a better focus on the communicational aspects. In the groups that started without the app, this effects of the app was even more apparent. Those participants reported to be more conscious about the aspects, which improved the structure of and the focus on those aspects, which ultimately led to better

decisions. Making better decisions with the app was an effect which all groups could agree on. It was reported that the improved argumentation evoked by the app leads to more thought through and more logical decisions. Only a few participants seemed to like the decisions without the app better, because they had the impression that the app inhibited the discussion and the resulting decisions.

4. *What influence has the use of technical support (the app) on the cognitive load during a collaborative decision making discussion?*

The use of the app resulted in a high cognitive load for the participants, which was generally perceived negative and inhibiting or distracting for the discussion.

This inhibition of the discussion is mentioned in different ways by almost all participants. The cognitive load was significantly perceived as negative and the participants only differed in how much it influenced them and their discussion. The groups that started with the app, described the app as distracting and inhibiting. Moreover they stated that it required time to use it and that the use was unclear and confusing, which made it even more distracting. Consistent with that, the groups that started without the app described the app as distracting and confusing. However, even though the members of group 2 mainly thought negatively about the cognitive load associated with the app, one of its members mentioned that the app could become less distracting and beneficial for the discussion if the discussion in general would be more structured. Similarly, even though two participants of group 4 agreed on the general negative attitude towards the high cognitive load caused by the app, the other two participants thought that the app did not have a negative influence on the cognitive load, but that it improved their focus and made the discussion more smooth. One participant initially thought that she would be distracted by the app, but found this to be not the case. This was in line with the opinion of another participant who stated that she got used to the app during the discussion.

5. *What influence has the use of technical support (the app) on the flow of the collaborative decision making discussion?*

The app had a negative influence on the flow of the discussion and is perceived as disrupting.

All groups found the flow in the discussion with the app to be disrupted and rated the flow to be better in the discussions without the app. Only one participant found the discussion with app to be more smooth because of the app.

6. *What other possible effects occur by using technical support in a collaborative design decision discussion that are not taken into account based on the literature research yet?*

All effects described above were due to the app. However, the different group dynamics, the different English skills, the setting of the experiment and especially the different topics also had an effect on the discussions.

The flow of the discussion for example, was generally described to be better in the second session, because the group members already knew each other. Also, it was disrupted by differences in English skills, especially in group 4. In addition to that, the group dynamic also seemed to be influencing the general discussion, even though it was perceived differently by individuals. Some participants stated that it was nice that they all agreed on some arguments, others thought this was negatively influencing the discussion, because it did not feel as a real discussion. Also, because of the setting, the participants reported each other to be more shy and inhibited in the first sessions. Reasons for that were that the recording was found to be intimidating and the communication felt awkward and forced. Those additional effects had only a small effect on the discussions and did not seem to have a major influence on the effects of the app. However, the topic seemed to have a big influence on all discussions. The topic "website" was perceived more positive and easier than the topic "bicycle parking". This resulted in better discussion and decisions for the topic "website". Therefore, some positive or negative influences that were found for the app could have been (partly) influenced by the topic of that discussion, especially regarding the decisions that were made.

8. Discussion

The results show that the app, as a prototype for a support tool for collaborative decision making discussions, can have both advantages and disadvantages for such a discussion. In the following section, those advantages and disadvantages and their possible consequences for the discussion will be discussed regarding existing literature.

Advantages:

The first benefit that is found by this research for the use of the app, is the improvement of the structure of the discussion. According to Antunes (2013), an app that supplies structural elements to improve a discussion makes the discussion more efficient and which results in better decisions. Additional to that, Poole et al. (1993) states that clearly defined issues also lead to better decisions. The results show that having pre-defined issues to talk about seems to have improved the structure in the way that it made more clear what the defined design questions were. Also it improved the decisions that were made compared to the sessions without app. The objective measurement of number of words supports these findings; less words in the sessions with app could mean less repetitions and less talking about things that were not relevant to the defined issues. A better structure could also explain the higher ratings found for the focus on the topic at hand in the discussions with app (Schoot-Uiterkamp, 2017) and the higher ratings for the focus on the discussion itself.

Another explanation for the improved focus on the topic at hand in the discussions with the app could be a higher awareness about being off-subject during a discussion. This awareness of the communicational aspects is needed, to have not only a good general structure of the discussion, but also a good structured communication (Owen, 2015). A good structured communication results in a good argumentation process leading to good collaborative decisions (Lee, 1997). As seen in the results, the app makes the participants aware of those communicational aspects, which indeed improves the structure and is crucial to achieve a common goal (Balzarotti et al., 2014). With an improved communicational structure it therefore seems to be a logical consequence that the participants generally report to have better and more thought through decisions for the discussions with the app.

However, the topic of the discussion also seems to influence the communicational structure, as well as the general structure of the discussion. There are two possible explanations regarding that influence. First, the app could be working better with a topic that is found to be more

interesting. Considering that groups discuss more in depth and more extensive about a topic they like and can identify with, and a better structure would then be more effective. Second, the effects could be mainly because of the topic, and the app could have had only a small effect on the structure. Results found by Versteegh (2017) show that more communicational aspects and more decisions are found for the discussion with app. Furthermore, results found by Warnke (2017) show a significant influence on turn-taking in the sessions with app and the more interesting topic (topic "website"). These results make it more likely that the app is more efficient if the topic is found to be interesting.

One participant also mentioned that the app helped structuring the second discussion, even though it was not used in that discussion. There is a possibility that the insight in the structural and communicational elements could lead to long term improvement, because the group becomes more aware of the underlying elements of the discussion by using the app. The app therefore could be able to improve the group's ability in structuring the discussion and especially the communication. Poole et al. (1993) reported similar findings in a study about impacts of a group decision support system (GDSS). They found that the GDSS caused a better insight into the procedures of the group process; an impact that Poole et al. (1993) suspect to evoke long term improvement of the group's ability to control their own group process.

Disadvantages:

The biggest disadvantage of the app appears to be that it seems to overburden the cognitive capacities of the participants. The app seems to be distracting, confusing, braking the flow of the discussion and the interviews show that it disturbs the focus on the discussion for some of the participants. This could be due to multiple possible reasons.

On the one hand, it could be possible that the impact on the cognitive load is high, because of the novelty of the app and the novelty of the situation it is used in. The participants have never worked with an app like that before and are not used to work with the app or having a discussion with an additional secondary task. If that is the case, training with the app and getting more accustomed to the setting of, and to using the secondary task in a discussion should lower the cognitive load and should reduce the negative influences. Watson et al. (1988) tested a GDSS and found a 20-minute training period sufficient for the user to get used to the system that they used. Also, groups that are more familiar with each other and used to discuss a design decision should have less problems integrating the app in the discussion.

On the other hand, the cognitive capacity could really be overburdened by the app and training could possibly not be helping. In that case the app could make the discussion less efficient by continually breaking flow of and focus on the discussion. This is an effect that Watson et al. (1988) also observed for an GDSS, regardless of the 20-minute training period they implemented in their experiment. However, the GDSS by used by Watson et al. (1988) was a more complex systems than the app used in this study and therefore, it is yet to determine whether or not a training period with the app previous to the discussions would reduce the cognitive load for the app used in this experiment.

Finally, the overburdening of the cognitive capacities could also result in the app being ignored and forgotten during the discussion, which would make it useless. According to the Handbook of Human Factors and Ergonomics Methods (2004), a task with a higher demand on cognitive capacities is more difficult and two tasks that are competing for cognitive capacity could lead to a decreased performance if they exceed the cognitive capacities of the subject. The results show that participants choose to concentrate on the discussion and tend to forget to use the app, when they perceive the app to be too distracting.

9. Limitations and recommendations for further research

First, the participants in this study were students. Even though they were used to group discussions, they did not know each other and were not trained to make design decisions. It is recommended to test the reproducibility of the effects found in this study with groups that discuss design decisions on a regular basis in a more or less consistent group. It should be investigated whether the structuring effect of the app and the positive influence on the communicational aspects would still have the same positive effect in such experienced groups. In addition it should be tested whether the negative effects of high cognitive load during the use of the app still remain, when the group is used to the setting and better trained in discussions regarding design decisions.

Second, the differences between the topics seemed to have a influence on the results and on the effect of the app. The results and the discussion showed that it seemed to be more likely to have better effects with the app, if the topic is of relevance and importance to the participants. However, the effects of the topic and the app are difficult to separate in this study and further research should investigate which effects are due to the app and which effects are due to the topic.

Third, one of the participants mentioned that the app helped structure the discussion without app, because of a learning effect which resulted in remembering and working with communicational aspects to improve the overall discussion. This learning effect should be investigated further, to see if the use of the app could have an long term effect of the groups abilities to engage in collaborative decision making discussions. If further research can find learning effects that improves discussions on the long term, the app could for example be used as a training tool for collaborative decision making discussions. This could give the opportunity to improve the discussion without the possible disadvantages of the app being permanently present.

Fourth, this research did not take individual differences into account, because the groups were diverse and the participants were selected randomly. However, one of the participants mentioned for example that she had difficulties with the high cognitive load caused by the app because the considered herself to be bad at multitasking. Further research could investigate if there are individual factors of the group members such as the ability to multitask personality

traits which also have an influence on the benefits and the disadvantages the app could have in a collaborative decision making process.

Last but not least, the app used in this research was only a prototype for a technical support tool in collaborative discussion making. The app as prototype seemed to work as intended and there was no comment on the workings of the prototype itself. However, one of the participants mentioned that she did not like the available buttons but would have liked it more if she had an additional button with the communicational aspect “building up on that”. Additionally, arguments could be split into more specific descriptions like: arguments based on fast thinking or arguments based on slow thinking (Kahnemann, 2011). This research was aimed on testing the general effect a technical support tool could have, therefore specifying the communicational aspects in more distinct aspects was not helpful for the purpose of the experiment, but could be subject to further research.

10. Conclusion

This research aimed to explore the effects of a technical support tool for collaborative decision making in a face-to-face discussion, by use of an app. The results show that the app improves the structure of the discussion as well as the structure of the communication. However, the cognitive load of using the app seems high, which makes the app distracting and confusing for some of the participants. Furthermore it was found that the app seems to be more effective for topics that the participants personally find interesting and easy to discuss. The interaction between the effect of the app and that of the topic has yet to be determined.

Regarding those results, the app seems to be a helpful training tool to improve the communication and the structure of a discussion in a design team during the collaborative decision making process. Again, it has to be considered that the use of the app comes with high cognitive costs, which could be detrimental to discussions on the long term.

Further research has yet to determine if a technical support tool comparable to the app used in this study, could be used as training tool for collaborative decision making discussions. The discussion would then benefit from the positive effects of a better structured discussion, and having a better argumentation due to awareness of communicational aspects. Furthermore, if the app is used as a training tool, the negative effect of overburdening the group members with a high cognitive load, possibly could be minimized, making their discussions more efficient in the long-run.

11. References

Antunes, P., Zurita, G., & Baloian, N. (2014). An application framework for developing collaborative handheld decision-making tools. *Behaviour & Information Technology*, *33*(5), 470-485.

Baarda, D. B., De Goede, M. P. M., & Teunissen, J. (2005). Basisboek kwalitatief onderzoek. *Handleiding voor het opzetten en uitvoeren van kwalitatief onderzoek*, 300-301.

Balzarotti, S., Piccini, L., Andreoni, G., & Ciceri, R. (2014). "I Know That You Know How I Feel": Behavioral and Physiological Signals Demonstrate Emotional Attunement While Interacting with a Computer Simulating Emotional Intelligence. *Journal of Nonverbal Behavior*, *38*(3), 283-299.

Bostrom, N. (2016). *Fundamental issues of artificial intelligence* (Vol. 376). V. C. Müller (Ed.). Berlin: Springer.

Conklin, J., & Begeman, M. L. (1988). gIBIS: A hypertext tool for exploratory policy discussion. *ACM Transactions on Information Systems (TOIS)*, *6*(4), 303-331.

Cook, D. J., Augusto, J. C., & Jakkula, V. R. (2009). Ambient intelligence: Technologies, applications, and opportunities. *Pervasive and Mobile Computing*, *5*(4), 277-298.

Corchado, J. M., Bajo, J., & Abraham, A. (2008). GerAmi: Improving healthcare delivery in geriatric residences. *IEEE Intelligent Systems*, *23*(2).

Druzdzel, M. J., & Flynn, R. R. (1999). Decision support systems. Encyclopedia of library and information science. A. Kent. *Marcel Dekker, Inc. Last Login*, *10*(03), 2002.

Fulk, J., & Steinfield, C. W. (Eds.). (1990). *Organizations and communication technology* (Vol. 1). Sage.

Johnson, D. W., & Johnson, F. (2014). Joining Together. Edinburgh Gate, Essex: Pearson Education Limited.

Kahneman, D. (2011). *Thinking, fast and slow*. Macmillan.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *biometrics*, 159-174.

Langer, E. J., Blank, A., & Chanowitz, B. (1978). The mindlessness of ostensibly thoughtful action: The role of" placebic" information in interpersonal interaction. *Journal of personality and social psychology*, *36*(6), 635.

Lee, J. (1997). Design rationale systems: understanding the issues. *IEEE expert*, *12*(3), 78-85.

Lesser, O., Naamani-Dery, L., Kalech, M., & Elovici, Y. (2017). Group Decision Support for Leisure Activities Using Voting and Social Networks. *Group Decision and Negotiation*, *26*(3), 473-494

Lunenburg, F. C. (2011). Decision making in organizations. *International journal of management, business, and administration*, *15*(1), 1-9.

Marques, G., Respício, A., & Afonso, A. P. (2016). A Mobile Recommendation System Supporting Group Collaborative Decision Making. *Procedia Computer Science*, *96*, 560-567.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational psychologist*, *38*(1), 43-52.

Negnevitsky, M. (2005). *Artificial intelligence: a guide to intelligent systems*. Pearson Education.

Nunamaker Jr, J. F., Applegate, L. M., & Konsynski, B. R. (1987). Facilitating group creativity: Experience with a group decision support system. *Journal of Management Information Systems*, *3*(4), 5-19.

Oviatt, S., Coulston, R., & Lunsford, R. (2004, October). When do we interact multimodally?: cognitive load and multimodal communication patterns. In *Proceedings of the 6th international conference on Multimodal interfaces* (pp. 129-136). ACM.

Owen, D. (2015). Collaborative decision making. *Decision Analysis*, *12*(1), 29-45.

Panzarasa, P., Jennings, N. R., & Norman, T. J. (2002). Formalizing Collaborative Decision-making and Practical Reasoning in Multi-agent Systems. *Journal of logic and computation*, *12*(1), 55-117.

Poole, M. S., Holmes, M., Watson, R., & DeSanctis, G. (1993). Group decision support systems and group communication: A comparison of decision making in computer-supported and nonsupported groups. *Communication Research*, *20*(2), 176-213.

Schoot Uiterkamp, Luc (2017) *The impact of using a discussion support system on discussions.*

Stanton, N. A., Hedge, A., Brookhuis, K., Salas, E., & Hendrick, H. W. (Eds.). (2004). *Handbook of human factors and ergonomics methods*. CRC press.

Startdocument Living Smart Campus (retrieved from: https://www.utwente.nl/organisatie/nieuws-events/dossier/2016/living-smart-campus/#wat-is-het-living-smart-campus-programma on 30-6-2017)

Viterbo, J., Endler, M., & Baptista, G. (2010). A two-tier approach for decentralized reasoning in ambient intelligence. *IEEE Intelligent Systems (to be published)*.

Watson, R. T., DeSanctis, G., & Poole, M. S. (1988). Using a GDSS to facilitate group consensus: some intended and unintended consequences. *Mis Quarterly*, 463-478.

Xinghang, J. D., Nada, M., & Guillaume, D. (2015). cooperative knowledge representation and classification: application for design projects. Paper presented at the IJCAI, Buenos Aires.

12. Appendix

12.1. Appendix 1: Structure of the groups

Table 8

Structure of groups

Group number	***Participant number***	***Session 1***	***Session 2***
1 (Pilot test)	1, 2, 3, 4	Without app – bicycle	With app – website
2	5, 6, 7, 8	With app - bicycle	Without app - website
3	9, 10, 11, 12	Without app - bicycle	With app- website
4	13, 14, 15, 16	With app - website	Without app - bicycle
5	17,18,19,20	Without app- website	With app - bicycle

12.2. Appendix 2: Design topics

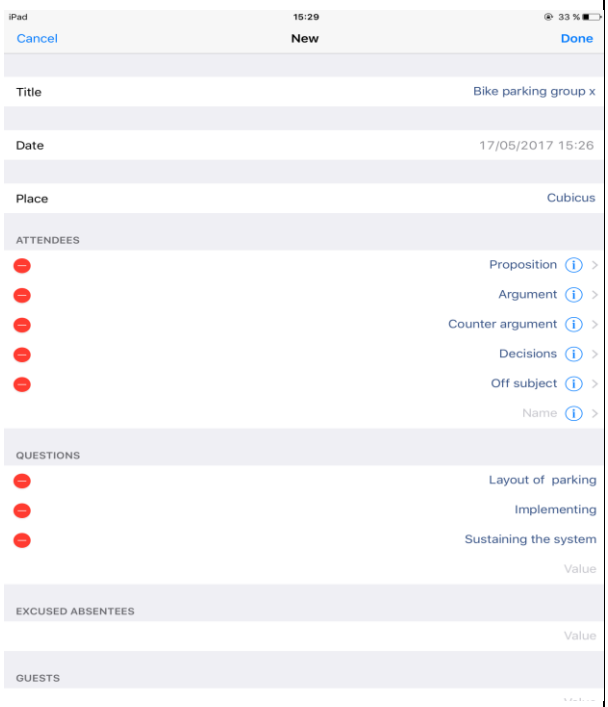
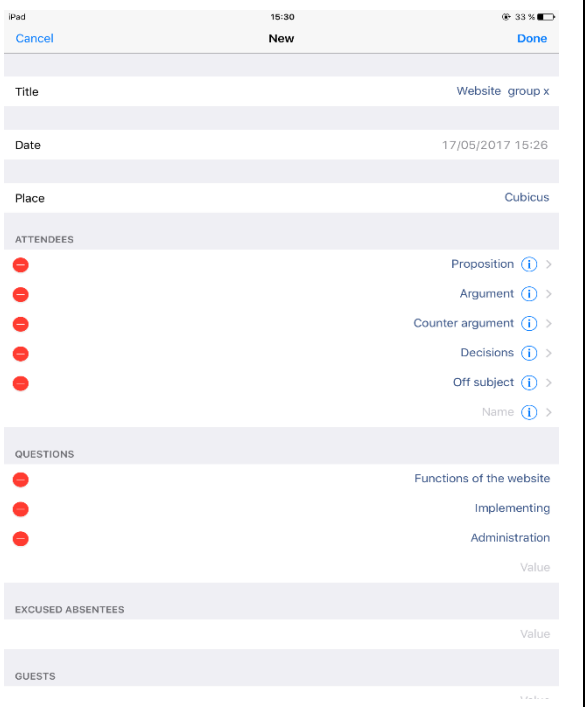
Table 9

Design topics

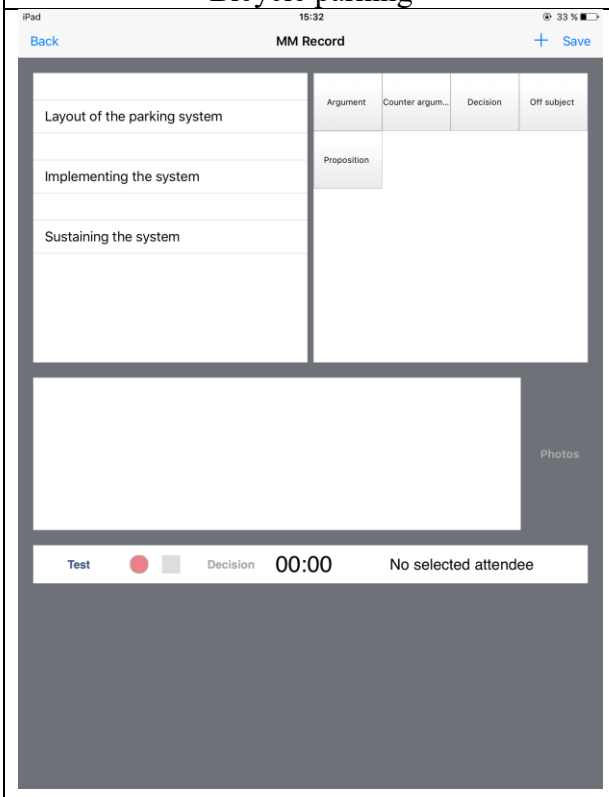
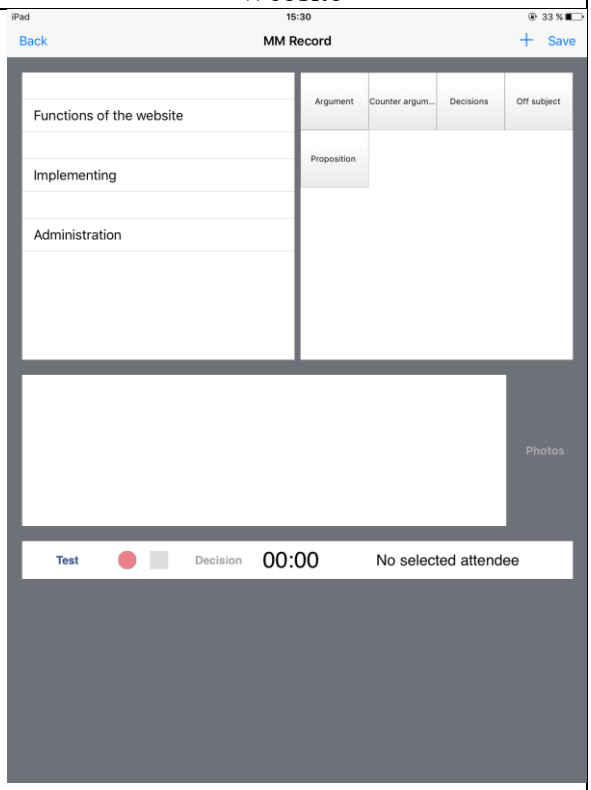
	Topic "bicycle parking"	***Topic "website"***
Main theme	Design a bicycle parking system for the university.	Website for student and employee communication. (something that combines e.g. buying/selling things, searching for room, planning parties, offer study support etc.)
Sub questions	1.) Structure of the parking system. (How will it actually look like?) 2.) Implementing the system (Are you going to need employees for everyday work or is it going to be automated?) 3.) Sustaining the system (how will you make sure that the system is used?)	1.) Functions of the website? (What should you be able to do on the website?) 2.) Implementation (how will you motivate students and employees to actively use the website?) 3.) Administration (Who is going to control the website?)

12.3. Appendix 3: Structure of the app

Display 1

Bicycle parking	Website
	

Display 2

Bicycle parking	Website
	

12.4. Appendix 4: Instructions for the session-instructor

The instructor needs:

1 copy of the page "groups", 1 copy of the page "instructions for the session-instructor", 1 copy of "form 1", 5 copies of the instruction sheet for the participants", 4 copies of the "informed consent", 4 empty pages for the participants to draw on, 1 copy of each interview.

A room to use for the discussion, 4 IPads with the app installed, equipment for audio and video recording.

Use of the IPad: The IPad needs the app MM Records and every app needs to be set as seen on display one and two.

1) Greeting of the participants	
2) Fill in Form 1	(only instructor
3) Set up mics and tablets	Not recording yet
4) Explain experiment and the set-up of the mics and tablets.	Information sheet for the participants
5) Time for questions	
6) Hand out informed consent	
7) Time for questions	
8) Start recording	
9) Start discussion	30 minutes
10) Stop recording	
11) Time for questions	
12) Interviews with audio recording	One by one, using the interview that is applicable (1 or 2), additionally use interview 3 if it is the second discussion
13) Time for questions	
14) Confirm date for second part with every participant or start over at point 2)	

12.5. Appendix 5: Form 1

To be filled in by the instructor, needed one time for every group

Date:

Group number:

Condition:

Participant numbers:

Important comments about the data collection:

12.6. Appendix 6: Information sheet for the participants

Condition 1: without app, design A

Instructions about the procedure:

You and your group will have 30 minutes to discuss a given subject. In this discussion, you have the possibility to draw or make notes on the given sheets, but this is not obligatory. Also it is not mandatory to actually make a decision or to talk about all three given questions if you think you don't have the time or if you cannot agree on something. It is more important to have a good discussion about possible options. In this discussion, you need to concentrate only on the discussion without doing any secondary tasks. The instructor will give a sign if the time is almost up (last five minutes) and when the time is up. Then you will be individually interviewed about the session. The data collected with the short interview will be used confidentially and will therefore only be registered with your participant number. Every part of this discussion will be filmed and recorded. All recordings will be treated confidentially. It is important for the audio recording that you try not to touch your microphone during the discussion.

In this session you will discuss the design of a bicycle parking system for the University of Twente. Our society is becoming smarter by implementing sensors everywhere, our environment is monitored and detected by computers, or social networks are becoming a trendy communication tool to share information which is changing our behavior etc. How does our bike parking system can use these new technologies to be more efficient. The three questions that you should consider in this design decision are:

1.) Layout of the parking system. (How will it actually look like? For example: where do you want it to be, do you want to focus your design on the whole campus or only on problem areas such as the *"O&O-plein",* do you want additional parking spots (how will that look like?) or use the old ones better (how?) etc.)

2.) Implementing the system (For example: are you going to need employees for everyday work or is it going to be automated?)

3.) Sustaining the system (For example: how will you make sure that the system is used?)

Instructions about the theory:

The questions that are defined above are entered in the app. You can see them on the left side of the screen. In the discussion, you, as a group, will decide with which of those three issue you want to start with. Whilst discussing the issue, the tablet will record what you say automatically and register it to your participant-ID. A discussion contains a number of elements typical for a good structure of discussions. Those are: proposition, argument, counter argument, off subject and decision. For example: To design a bike, you could discuss about material. A proposition then would be gold. An argument could be because it is shiny, a counter argument could be that it will most likely be stolen very quickly. Off subject would then be to talk about functions the bike should have or about thievery in Enschede.

Condition 1: without app, design B

Instructions about the procedure:

You and your group will have 30 minutes to discuss a given subject. In this discussion, you have the possibility to draw or make notes on the given sheets, but this is not obligatory. Also it is not mandatory to actually make a decision or to talk about all three given questions if you think you don't have the time or if you cannot agree on something. It is more important to have a good discussion about possible options. In this discussion, you need to concentrate only on the discussion without doing any secondary tasks. The instructor will give a sign if the time is almost up (last five minutes) and when the time is up. Then you will be individually interviewed about the session. The data collected with the short interview will be used confidentially and will therefore only be registered with your participant number. Every part of this discussion will be filmed and recorded. All recordings will be treated confidentially. It is important for the audio recording that you try not to touch your microphone during the discussion.

In this session you will discuss the design of a website for student and employee communication. Imagine a website, that combines e.g. buying/selling things like on the Facebook market place of the university, searching for a room on the campus or in the city, like for example on kamernet, planning parties, offer study support etc. How could you combine all those features in one website? The three questions that you should consider in this design decision are:

1.) Functions of the website (What should you be able to do on the website?)

2.) Implementation (how will you motivate students and employees to actively use the website?)

3.) Administration (Who is going to control the website?)

Instructions about the theory:

The questions that are defined above are entered in the app. You can see them on the left side of the screen. In the discussion, you, as a group, will decide with which of those three issue you want to start with. Whilst discussing the issue, the tablet will record what you say automatically and register it to your participant-ID. A discussion contains a number of elements typical for a good structure of discussions. Those are: proposition, argument, counter argument, off subject and decision. For example: To design a bike, you could discuss about material. A proposition then would be gold. An argument could be because it is shiny, a counter argument could be that it will most likely be stolen very quickly. Off subject would then be to talk about functions the bike should have or about thievery in Enschede.

Condition 2: with app, design A

Instructions about the procedure:

You and your group will have 30 minutes to discuss a given subject. In this discussion, you have the possibility to draw or make notes on the given sheets, but this is not obligatory. Also it is not mandatory to actually make a decision or to talk about all three given questions if you think you don't have the time or if you cannot agree on something. It is more important to have a good discussion about possible options. It is more important to have a good discussion about possible options. In this discussion, you also need to concentrate on a secondary tasks (described further in the instructions about the theory and the app). The instructor will give a sign if the time is almost up (last five minutes) and when the time is up. Then you will be individually interviewed about the session. The data collected with the short interview will be used confidentially and will therefore only be registered with your participant number. Every part of this discussion will be filmed and recorded. All recordings will be treated confidentially. It is important for the audio recording that you try not to touch your microphone during the discussion.

In this session you will discuss the design of a bicycle parking system for the University of Twente. Our society is becoming smarter by implementing sensors everywhere, our environment is monitored and detected by computers, or social networks are becoming a trendy communication tool to share information which is changing our behavior etc. How does our bike parking system can use these new technologies to be more efficient. The three questions that you should consider in this design decision are:

1.) Layout of the parking system. (How will it actually look like? For example: where do you want it to be, do you want to focus your design on the whole campus or only on problem areas such as the *"O&O-plein",* do you want additional parking spots (how will that look like?) or use the old ones better (how?) etc.)

2.) Implementing the system (For example: are you going to need employees for everyday work or is it going to be automated?)

3.) Sustaining the system (For example: how will you make sure that the system is used?)

Instructions about the theory and the app:

The questions that are defined above are entered in the app. You can see them on the left side of the screen. In the discussion, you, as a group, will decide with which of those three issue you want to start with. Whilst discussing the issue, the tablet will record what you say automatically and register it to your participant-ID. A discussion contains a number of elements typical for a good structure of discussions. Those are: proposition, argument, counter argument, off subject and decision. For example: To design a bike, you could discuss about material. A proposition then would be gold. An argument could be because it is shiny, a counter argument could be that it will most likely be stolen very quickly. Off subject would then be to talk about functions the bike should have or about thievery in Enschede. During the discussion every group member will have the option to choose between five different buttons to press, representing the five structure elements mentioned above. Every time a group member says something, every member of the group (also the one who is speaking) taps one of those provided buttons accordingly to what he/she thinks the group member is talking about. You do not need to push the button if you think the things said are not fitting into one of the given definitions. The decision button is only used to record the final decision for that issue. If the instructor sees that you, or members of your group, forget to push the buttons, he/she will remind you during the discussion

Condition 2: with app, design B

Instructions about the procedure:

You and your group will have 30 minutes to discuss a given subject. In this discussion, you have the possibility to draw or make notes on the given sheets, but this is not obligatory. Also it is not mandatory to actually make a decision if you think you don't have the time or if you cannot agree on something. It is more important to have a good discussion about possible options. In this discussion, you also need to concentrate on a secondary tasks (described further in the instructions about the theory and the app).The instructor will give a sign if the time is almost up (last five minutes) and when the time is up. Then you will be individually interviewed about the session. The data collected with the short interview will be used confidentially and will therefore only be registered with your participant number. Every part of this discussion will be filmed and recorded. All recordings will be treated confidentially. It is important for the audio recording that you try not to touch your microphone during the discussion.

In this session you will discuss the design of a website for student and employee communication. Imagine a website, that combines e.g. buying/selling things like on the Facebook market place of the university, searching for a room on the campus or in the city, like for example on kamernet, planning parties, offer study support etc. How could you combine all those features in one website? The three questions that you should consider in this design decision are:

1.) Functions of the website (What should you be able to do on the website?)

2.) Implementation (how will you motivate students and employees to actively use the website?)

3.) Administration (Who is going to control the website?)

Instructions about the theory and the app:

The questions that are defined above are entered in the app. You can see them on the left side of the screen. In the discussion, you, as a group, will decide with which of those three issue you want to start with. Whilst discussing the issue, the tablet will record what you say automatically and register it to your participant-ID. A discussion contains a number of elements typical for a good structure of discussions. Those are: proposition, argument, counter argument, off subject and decision. For example: To design a bike, you could discuss about material. A proposition then would be gold. An argument could be because it is shiny, a counter argument could be that it will most likely be stolen very quickly. Off subject would then be to talk about functions the bike should have or about thievery in Enschede. During the discussion every group member will have the option to choose between five different buttons to press, representing the five structure elements mentioned above. Every time a group member says something, every member of the group (also the one who is speaking) taps one of those provided buttons accordingly to what he/she thinks the group member is talking about. You do not need to push the button if you think the things said are not fitting into one of the given definitions. The decision button is only used to record the final decision for that issue. If the instructor sees that you, or members of your group, forget to push the buttons, he/she will remind you during the discussion.

12.7. Appendix 7: Instructions for the participants given by the instructor

Instructions without app

Instructions with app

- ***In this session it is important to use the app as much as possible***
- Not mandatory to make a decision or talk about all three points, focus on the discussion itself
- Ask them to explain in their own words:
    - What is a proposition?
    - What is an argument?
    - What is a counter argument?
    - What is off subject?
    - What is a decision?
- ***You now have a moment to look at the app, as you can see there are five buttons which match with the communicational aspects we just discussed.***
- ***In the discussion <u>every time</u> someone says something (that includes yourself!) you have to choose if one of the buttons fits the said statement and press that button.***
- ***In this session it is important to use the app as much as possible***
- ***So if I would now give a proposition:***
    - ***What could that be?***
    - ***What would you and I have to do? (press the button proposition on the app)***
- ***And if I or someone else then would give an argument for that proposition:***
    - ***As e.g.?***
    - ***What would we have to do then? (press the button argument)***
- ***It is important to try to remember pressing the buttons the whole 30 minutes, if I see that you are not pressing any buttons I will remember you to do so by tapping on your shoulder***

12.8. Appendix 8: Informed consent

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	☐
2.	I have been given the opportunity to ask questions about the project and my participation.	☐
3.	I voluntarily agree to participate in the project.	☐
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalized for withdrawing nor will I be questioned on why I have withdrawn.	☐
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymization of data, etc.) to me.	☐
6.	The procedures regarding confidentiality for interviews, audio, video or other forms of data collection have been explained to me.	☐
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	☐
8.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	☐
9.	I, along with the Researcher, agree to sign and date this informed consent form.	☐

Age: **Gender:** female / male **Study:**

Participant:

_____ _____ _____

Name of Participant Signature Date

Researcher:

_____ _____ _____

Name of Researcher Signature Date

12.9. Appendix 9: Questionnaire

Hello, **Discussion 1**

Thank you for filling in this questionnaire. It consists of eleven questions where you should indicate the statement that fits most with your feelings regarding the question. Indication should be made by filling in the circle above the statement.

Sona number: _____ **Used app this discussion:** O Yes / O No

How many contributions (arguments, counterarguments and proposals) did you feel like you have made?				
O *Very little*	O *Little*	O *Not very little; not very much*	O *Much*	O *Very much*
What was the quality of the decision made at the end of the discussion?				
O *Very poor*	O *Poor*	O *Not poor; not well*	O *Quite well*	O *Very well*
What was the quality of the discussion in general?				
O *Very poor*	O *Poor*	O *Not poor; not good*	O *Quite good*	O *Very good*
How effective was the discussion?				
O *Not at all effective*	O *Not very effective*	O *Not ineffective; not very effective*	O *Quite effective*	O *Very effective*
How clear was the communication flow?				
O *Not at all clear*	O *Not very clear*	O *Not unclear; not clear*	O *Quite clear*	O *Very clear*
How structured was the discussion?				
O *Not at all structured*	O *Not very structured*	O *Not badly structured; not well structured*	O *Quite well structured*	O *Very well structured*
How focussed was the discussion? (Was it on-topic?)				
O *Not at all focussed*	O *Not well focussed*	O *Not badly focussed; not well focussed*	O *Quite well focussed*	O *Very well focussed*
How clear was the content of the discussion for you?				
O *Not at all clear*	O *Not very clear*	O *Not unclear; not clear*	O *Quite clear*	O *Very clear*
What was the depth of the discussion?				
O *Very shallow*	O *Shallow*	O *Not shallow; not deep*	O *Quite deep*	O *Very deep*
How much did you participate in the discussion?				
O *Very little*	O *Little*	O *Not little; not much*	O *Quite a lot*	O *Very much*
How much collaboration took place during the discussion?				
O *Very little*	O *Little*	O *Not little; not much*	O *Quite a lot*	O *Very much*

Hello, **Discussion 2**

Thank you for filling in this questionnaire. It consists of eleven questions where you should indicate the statement that fits most with your feelings regarding the question. Indication should be made by filling in the circle above the statement.

Sona number: _____ **Used app this discussion:** O Yes / O No

How many contributions (arguments, counterarguments and proposals) did you feel like you have made?				
O *Very little*	O *Little*	O *Not very little; not very much*	O *Much*	O *Very much*
What was the quality of the decision made at the end of the discussion?				
O *Very poor*	O *Poor*	O *Not poor; not well*	O *Quite well*	O *Very well*
What was the quality of the discussion in general?				
O *Very poor*	O *Poor*	O *Not poor; not good*	O *Quite good*	O *Very good*
How effective was the discussion?				
O *Not at all effective*	O *Not very effective*	O *Not ineffective; not very effective*	O *Quite effective*	O *Very effective*
How clear was the communication flow?				
O *Not at all clear*	O *Not very clear*	O *Not unclear; not clear*	O *Quite clear*	O *Very clear*
How structured was the discussion?				
O *Not at all structured*	O *Not very structured*	O *Not badly structured; not well structured*	O *Quite well structured*	O *Very well structured*
How focussed was the discussion? (Was it on-topic?)				
O *Not at all focussed*	O *Not well focussed*	O *Not badly focussed; not well focussed*	O *Quite well focussed*	O *Very well focussed*
How clear was the content of the discussion for you?				
O *Not at all clear*	O *Not very clear*	O *Not unclear; not clear*	O *Quite clear*	O *Very clear*
What was the depth of the discussion?				
O *Very shallow*	O *Shallow*	O *Not shallow; not deep*	O *Quite deep*	O *Very deep*
How much did you participate in the discussion?				
O *Very little*	O *Little*	O *Not little; not much*	O *Quite a lot*	O *Very much*
How much collaboration took place during the discussion?				
O *Very little*	O *Little*	O *Not little; not much*	O *Quite a lot*	O *Very much*

12.10. Appendix 10: Interviews

<u>Interview 1</u> *(decision making with app)*

1.) What do you think about your discussion?

- What do you think about the structure of your discussion?
- What do you think about the structure of your communication?
- How would you describe the focus on the defined issue in the group?
- What do you think about your decision(s)?

2.) What do you think about the communication?

- Do you think the app influenced the communication? How?
- How did the app influence your focus on the discussion?
- How did the app influence your focus on the communicational aspects that are pointed out by the app (buttons)?

3.) Do you have any other comments or questions?

<u>Interview 2</u> *(decision making without app)*

1.) What do you think about your discussion?

- What do you think about the structure of your discussion?
- What do you think about the structure of your communication?
- How would you describe the focus on the defined issue in the group?
- What do you think about your decision (s)?

2.) Do you have any other comments or questions?

<u>Interview 3</u> *(comparing the two decision making processes)*

1.) **What are the differences you perceived, comparing the decision making without the app to the decision making with the app?**

Regarding the:

- Discussion
- Structure
- Workflow
- Decision

2.) **Do you have any other comments or questions?**

12.11. Appendix 11: Cohen's kappa

Table 10

Example table interview P19 with calculations for the sensitizing concepts

		Rater 1									
		Discussion	*Topic*	*Communicational aspects*	*Decision*	*Group*	*Cognitive load*	*App*	*Setting*	*Not Coded*	
	Discussion	13								1	14
	Topic	1	1								2
	Communicational aspects			12						1	13
Rater 2	*Decision*				3						3
	Group					3				1	4
	Cognitive load						2				2
	App							2			2
	Setting								1		1
	Not coded										0
		14	1	12	3	3	2	2	1	3	41

$$k = \frac{\left(\frac{37}{41}\right) - \left(\frac{4{,}78 + 0{,}05 + 3{,}8 + 0{,}22 + 0{,}29 + 0{,}1 + 0{,}1 + 0{,}02}{41}\right)}{1 - \left(\frac{4{,}78 + 0{,}05 + 3{,}8 + 0{,}22 + 0{,}29 + 0{,}1 + 0{,}1 + 0{,}02}{41}\right)} = \frac{0{,}9 - 0{,}23}{1 - 0{,}23} = \frac{0{,}67}{0{,}77} = 0{,}87$$

Table 11

Example table interview P19 with calculations for the variation codes

		Rater 1				
		Positive	Negative	Neutral	Not coded	
Rater 2	Positive	22		1		23
	Negative		7		1	8
	Neutral			8	2	10
	Not coded					
		22	7	9	3	41

$$k = \frac{\left(\frac{37}{41}\right) - \left(\frac{12{,}34 + 1{,}37 + 2{,}2}{41}\right)}{1 - \left(\frac{12{,}34 + 1{,}37 + 2{,}2}{41}\right)} = \frac{0{,}9 - 0{,}38}{1 - 0{,}38} = \frac{0{,}52}{0{,}62} = 0{,}84$$

Calculations Cohen's kappa:

Interview P7:

Sensitizing concepts:

$$k = \frac{\left(\frac{62}{64}\right) - \left(\frac{11{,}81 + 0{,}19 + 0{,}39 + 0{,}56 + 0{,}14 + 1{,}27 + 1 + 0{,}04}{64}\right)}{1 - \left(\frac{11{,}81 + 0{,}19 + 0{,}39 + 0{,}56 + 0{,}14 + 1{,}27 + 1 + 0{,}04}{64}\right)} = \frac{0{,}97 - 0{,}23}{1 - 0{,}23} = \frac{0{,}74}{0{,}77} = 0{,}96$$

Theme codes:

$$k = \frac{\left(\frac{61}{64}\right) - \left(\frac{2{,}64 + 0{,}09 + 0{,}12 + 1{,}72 + 0{,}31 + 0{,}06 + 0{,}47 + 0{,}14 + 1{,}56 + 0{,}77}{64}\right)}{1 - \left(\frac{2{,}64 + 0{,}09 + 0{,}12 + 1{,}72 + 0{,}31 + 0{,}06 + 0{,}47 + 0{,}14 + 1{,}56 + 0{,}77}{64}\right)} = \frac{0{,}95 - 0{,}12}{1 - 0{,}12} = \frac{0{,}74}{0{,}79} = 0{,}94$$

Variation codes:

$$k = \frac{\left(\frac{61}{64}\right) - \left(\frac{4{,}5 + 17{,}53 + 1{,}72 + 0{,}06 + 0{,}02}{64}\right)}{1 - \left(\frac{4{,}5 + 17{,}53 + 1{,}72 + 0{,}06 + 0{,}02}{64}\right)} = \frac{0{,}95 - 0{,}37}{1 - 0{,}37} = \frac{0{,}58}{0{,}63} = 0{,}92$$

Interview P12:

Sensitizing concepts:

$$k = \frac{\left(\frac{55}{57}\right) - \left(\frac{5{,}37 + 0{,}16 + 0{,}63 + 1{,}42 + 0{,}07 + 1{,}58 + 0{,}28 + 0{,}44}{57}\right)}{1 - \left(\frac{5{,}37 + 0{,}16 + 0{,}63 + 1{,}42 + 0{,}07 + 1{,}58 + 0{,}28 + 0{,}44}{57}\right)} = \frac{0{,}96 - 0{,}17}{1 - 0{,}17} = \frac{0{,}79}{0{,}83} = 0{,}95$$

Theme codes:

$$k = \frac{\left(\frac{55}{57}\right) - \left(\frac{1{,}42 + 0{,}28 + 0{,}44 + 1{,}58 + 0{,}48 + 0{,}56 + 0{,}53 + 0{,}04}{57}\right)}{1 - \left(\frac{1{,}42 + 0{,}28 + 0{,}44 + 1{,}58 + 0{,}48 + 0{,}56 + 0{,}53 + 0{,}04}{57}\right)} = \frac{0{,}96 - 0{,}08}{1 - 0{,}08} = \frac{0{,}88}{0{,}92} = 0{,}96$$

Variation codes:

$$k = \frac{\left(\frac{53}{57}\right) - \left(\frac{14{,}74 + 6{,}33 + 0{,}74 + 0{,}02}{57}\right)}{1 - \left(\frac{14{,}74 + 6{,}33 + 0{,}74 + 0{,}02}{57}\right)} = \frac{0{,}92 - 0{,}38}{1 - 0{,}38} = \frac{0{,}54}{0{,}62} = 0{,}87$$

Interview P14:

Sensitizing concepts:

$$k = \frac{\left(\frac{78}{87}\right) - \left(\frac{10{,}69 + 0{,}55 + 1{,}94 + 4{,}8 + 0{,}09 + 0{,}34 + 0{,}1}{87}\right)}{1 - \left(\frac{10{,}69 + 0{,}55 + 1{,}94 + 4{,}8 + 0{,}09 + 0{,}34 + 0{,}1}{87}\right)} = \frac{0{,}9 - 0{,}21}{1 - 0{,}21} = \frac{0{,}69}{0{,}79} = 0{,}87$$

Theme codes:

$$k = \frac{\left(\frac{78}{87}\right) - \left(\frac{2{,}09 + 0{,}41 + 0{,}14 + 0{,}1 + 3{,}32 + 0{,}23 + 0{,}83 + 0{,}02 + 0{,}07 + 0{,}36 + 0{,}03 + 0{,}25}{87}\right)}{1 - \left(\frac{2{,}09 + 0{,}41 + 0{,}14 + 0{,}1 + 3{,}32 + 0{,}23 + 0{,}83 + 0{,}02 + 0{,}07 + 0{,}36 + 0{,}03 + 0{,}25}{87}\right)} = \frac{0{,}9 - 0{,}09}{1 - 0{,}09} = \frac{0{,}81}{0{,}91} = 0{,}89$$

Variation codes:

$$k = \frac{\left(\frac{78}{87}\right) - \left(\frac{24{,}22 + 6{,}9 + 0{,}92 + 0{,}1}{87}\right)}{1 - \left(\frac{24{,}22 + 6{,}9 + 0{,}92 + 0{,}1}{87}\right)} = \frac{0{,}9 - 0{,}37}{1 - 0{,}37} = \frac{0{,}53}{0{,}63} = 0{,}84$$

Interview P19:

Sensitizing concepts:

$$k = \frac{\left(\frac{37}{41}\right) - \left(\frac{4{,}78 + 0{,}05 + 3{,}8 + 0{,}22 + 0{,}29 + 0{,}1 + 0{,}1 + 0{,}02}{41}\right)}{1 - \left(\frac{4{,}78 + 0{,}05 + 3{,}8 + 0{,}22 + 0{,}29 + 0{,}1 + 0{,}1 + 0{,}02}{41}\right)} = \frac{0{,}9 - 0{,}23}{1 - 0{,}23} = \frac{0{,}67}{0{,}77} = 0{,}87$$

Theme codes:

$$k = \frac{\left(\frac{36}{41}\right) - \left(\frac{0{,}73 + 0{,}1 + 1{,}2 + 0{,}1 + 0{,}15 + 0{,}05 + 0{,}1 + 0{,}05 + 0{,}02 + 0{,}1 + 0{,}02 + 0{,}22 + 0{,}2 + 0{,}08}{41}\right)}{1 - \left(\frac{0{,}73 + 0{,}1 + 1{,}2 + 0{,}1 + 0{,}15 + 0{,}05 + 0{,}1 + 0{,}05 + 0{,}02 + 0{,}1 + 0{,}02 + 0{,}22 + 0{,}2 + 0{,}08}{41}\right)} = \frac{0{,}9 - 0{,}08}{1 - 0{,}08} = \frac{0{,}82}{0{,}92} = 0{,}89$$

Variation codes:

$$k = \frac{\left(\frac{37}{41}\right) - \left(\frac{12{,}34 + 1{,}37 + 2{,}2}{41}\right)}{1 - \left(\frac{12{,}34 + 1{,}37 + 2{,}2}{41}\right)} = \frac{0{,}9 - 0{,}38}{1 - 0{,}38} = \frac{0{,}52}{0{,}62} = 0{,}84$$

12.12. Appendix 12: Results

The results are shown in 3 tables for each group, containing the results for 1) session 1, 2) session 2 and 3) the comparison of both sessions. The numbers in the tables indicate the number of statements made for that label.

Table 12

Group 2: Session one – with app – bike parking

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence	1	1	1
	Use	1		1
Cognitive load				
	No secondary task			
	Secondary task		1	8
	Secondary task other than app			
Communicational aspects				
	Arguments			2
	Conscious about them	1	2	
	Counter-arguments			
	Decision			1
	Focus	2		3
	General		1	
	Off subject			1
	Proposition	1		1
	Structure			3
Decision				
	Content	2		2
	Dependent on issue			
	Dependent on topic			1
	Depth			2
	General	4	1	2
	Influenced by attributes of participants			1
Discussion				
	Communication	3	2	2
	Content			
	Depth			3
	Flow			4
	Focus	3		7
	General			1
	Structure	2	1	11
Group				
	Attributes of participants		1	

	Dynamic	1	1	4
	Participant contribution			
Setting				
	General			2
	Recording			1
	Time		1	
Topic				
	Content of topic bike	1	1	4
	Content of topic website			
	Depth			
	Focus			
	General			
	Influenced by attributes of participants			1

Table 13

Group 2: Session two – without app – website

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence			
	Use			
Cognitive load				
	No secondary task	3		
	Secondary task			
	Secondary task other than app			
Communicational aspects				
	Arguments		1	
	Conscious about them			3
	Counter-arguments			1
	Decision		1	
	Focus			1
	General			
	Off subject			
	Proposition		1	
	Structure			
Decision				
	Content	2	1	
	Dependent on issue	1		1
	Dependent on topic	1		
	Depth	1		
	General	2		

	Influenced by attributes of participants		1	
Discussion				
	Communication	2		
	Content	1		
	Depth			1
	Flow	2		
	Focus	4		3
	General	2		1
	Structure	1	1	4
Group				
	Attributes of participants			
	Dynamic	1		1
	Participant contribution			
Setting				
	General		1	1
	Recording			1
	Time			
Topic				
	Content of topic bike			
	Content of topic website	2	1	1
	Depth			
	Focus		1	1
	General			
	Influenced by attributes of participants			

Table 14

Group 2: Comparison

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence		1	
	Use			1
Cognitive load				
	No secondary task	4		
	Secondary task	1		5
	Secondary task other than app			
Communicational aspects				
	Arguments			
	Conscious about them			
	Counter-arguments			

	Decision			
	Focus			
	General			
	Off subject			
	Proposition			
	Structure			
	Arguments with app	1		
	Conscious about them with app	2	1	
	Counter-arguments with app	2		
	Decision with app			
	Focus with app			
	General with app			
	Off subject with app			
	Proposition with app	1		
	Structure with app			1
	Arguments without app			
	Conscious about them without app			
	Counter-arguments without app			
	Decision without app			
	Focus without app			
	General without app			
	Off subject without app			
	Proposition without app			1
	Structure without app			1
Decision				
	Content			
	Dependent on issue			
	Dependent on topic			1
	Depth			
	General		3	
	Influenced by attributes of participants			
	Content with app			
	Dependent on issue with app			
	Dependent on topic with app			
	Depth with app	1		
	General with app			
	Influenced by attributes of participants with app			
	Content without app			
	Dependent on issue without app			
	Dependent on topic without app			

	Depth without app	1		
	General without app	1		
	Influenced by attributes of participants without app			
Discussion				
	Communication		1	
	Content			
	Depth			
	Flow		1	
	Focus			
	General			
	Structure		2	
	Communication with app			
	Content with app			
	Depth with app	1		
	Flow with app			2
	Focus with app			2
	General with app			
	Structure with app	2		
	Communication without app	2		
	Content without app	1		
	Depth without app	1		
	Flow without app	4	1	
	Focus without app	3		
	General without app	1		
	Structure without app			3
Group				
	Attributes of participants			
	Dynamic			
	Participant contribution			
Setting				
	General		1	2
	Recording			
	Time			1
Topic				
	Content of topic bike			
	Content of topic website	2		
	Depth			
	Focus			
	General			
	Influenced by attributes of participants			

Table 15

Group 3: Session one – without app – bike parking

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence			
	Use			
Cognitive load				
	No secondary task			
	Secondary task			
	Secondary task other than app	2		
Communicational aspects				
	Arguments	1	1	
	Conscious about them	1		
	Counter-arguments			1
	Decision			
	Focus			
	General			
	Off subject			1
	Proposition		1	
	Structure			2
Decision				
	Content	1		
	Dependent on issue			
	Dependent on topic			1
	Depth			1
	General	4		1
	Influenced by attributes of participants			
Discussion				
	Communication			1
	Content			
	Depth			
	Flow			
	Focus	3	2	3
	General	2		
	Structure		1	3
Group				
	Attributes of participants			
	Dynamic	3		4
	Participant contribution	1		
Setting				
	General			1
	Recording			1
	Time			

Topic				
	Content of topic bike			3
	Content of topic website			
	Depth			
	Focus			
	General			
	Influenced by attributes of participants		1	

Table 16

Group 3: Session two – with app – website

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			1
	General influence	1	2	
	Use	2		1
Cognitive load				
	No secondary task			
	Secondary task	1	2	5
	Secondary task other than app			
Communicational aspects				
	Arguments	1		
	Conscious about them	7		2
	Counter-arguments	2		
	Decision	1		
	Focus	7		
	General			
	Off subject	1		
	Proposition	1		
	Structure	3	1	
Decision				
	Content			2
	Dependent on issue	1		2
	Dependent on topic			1
	Depth			
	General	4		1
	Influenced by attributes of participants			
Discussion				
	Communication	4		1
	Content	1		
	Depth			
	Flow	1		
	Focus	10	1	1

	General	4		1
	Structure	6		
Group				
	Attributes of participants			
	Dynamic	2		3
	Participant contribution		1	3
Setting				
	General			
	Recording			
	Time			1
Topic				
	Content of topic bike			
	Content of topic website	2		
	Depth			
	Focus			
	General			
	Influenced by attributes of participants			

Table 17

Group 3: Comparison

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			1
	General influence		2	
	Use	1		
Cognitive load				
	No secondary task			
	Secondary task	1		1
	Secondary task other than app			
Communicational aspects				
	Arguments			
	Conscious about them			
	Counter-arguments	1		
	Decision			
	Focus			
	General			
	Off subject			
	Proposition			
	Structure			
	Arguments with app			
	Conscious about them with app	4		
	Counter-arguments with app			

	Decision with app	1		
	Focus with app			
	General with app			
	Off subject with app			
	Proposition with app			
	Structure with app	1		
	Arguments without app			
	Conscious about them without app			
	Counter-arguments without app			
	Decision without app			
	Focus without app			
	General without app			
	Off subject without app			
	Proposition without app			
	Structure without app			
Decision				
	Content			
	Dependent on issue			
	Dependent on topic	1	1	
	Depth		1	
	General			
	Influenced by attributes of participants			
	Content with app			
	Dependent on issue with app			
	Dependent on topic with app			
	Depth with app	2		
	General with app	2		
	Influenced by attributes of participants with app			
	Content without app			
	Dependent on issue without app			
	Dependent on topic without app			
	Depth without app			1
	General without app	1		1
	Influenced by attributes of participants without app			
Discussion				
	Communication			
	Content			
	Depth			
	Flow			
	Focus			

	General	1	1	
	Structure			
	Communication with app			
	Content with app			
	Depth with app	1		
	Flow with app	2		1
	Focus with app	2		
	General with app			
	Structure with app	6		
	Communication without app			
	Content without app			
	Depth without app			
	Flow without app			
	Focus without app			2
	General without app	3		
	Structure without app	1		
Group				
	Attributes of participants			
	Dynamic	1	1	1
	Participant contribution	1		
Setting				
	General			
	Recording		1	
	Time			
Topic				1
	Content of topic bike			
	Content of topic website	2		
	Depth			
	Focus			
	General			
	Influenced by attributes of participants			

Table 18

Group 4: Session one – with app – website

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence	4		
	Use	2	1	2
Cognitive load				
	No secondary task			
	Secondary task			5
	Secondary task other than app			1
Communicational aspects				
	Arguments	1	1	1
	Conscious about them	8		
	Counter-arguments		1	2
	Decision	2		
	Focus	3		1
	General			
	Off subject	1		
	Proposition	3	1	
	Structure	4	1	1
Decision				
	Content			
	Dependent on issue			
	Dependent on topic			
	Depth			
	General	3		
	Influenced by attributes of participants			
Discussion				
	Communication	5		1
	Content			1
	Depth			
	Flow			5
	Focus	6		2
	General	3	1	
	Structure	6	1	5
Group				
	Attributes of participants			
	Dynamic	7	2	3
	Participant contribution	2		3
Setting				
	General		1	
	Recording			
	Time			2

Topic				
	Content of topic bike			
	Content of topic website	1		3
	Depth			
	Focus			
	General			
	Influenced by attributes of participants			

Table 19

Group 4: Session two – without app – bicycle parking

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence	1		
	Use			
Cognitive load				
	No secondary task	1		
	Secondary task			
	Secondary task other than app			
Communicational aspects				
	Arguments		1	
	Conscious about them	1		1
	Counter-arguments			
	Decision			
	Focus			1
	General			
	Off subject			1
	Proposition			
	Structure	1	1	
Decision				
	Content			2
	Dependent on issue			
	Dependent on topic			
	Depth			3
	General	2	1	3
	Influenced by attributes of participants			
Discussion				
	Communication	1		1
	Content			3
	Depth			1
	Flow	2		1
	Focus		1	2

	General	2	1	
	Structure	3		4
Group				
	Attributes of participants			
	Dynamic		1	1
	Participant contribution			1
Setting				
	General			
	Recording			
	Time			2
Topic				
	Content of topic bike			4
	Content of topic website			
	Depth			
	Focus			
	General			
	Influenced by attributes of participants			

Table 20

Group 4: Comparison

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence	4		
	Use			
Cognitive load				
	No secondary task	2		
	Secondary task			1
	Secondary task other than app			
Communicational aspects				
	Arguments			
	Conscious about them			
	Counter-arguments			
	Decision			
	Focus			
	General			
	Off subject			
	Proposition			
	Structure			
	Arguments with app	1		
	Conscious about them with app	3		

	Counter-arguments with app			
	Decision with app	1		
	Focus with app			1
	General with app			
	Off subject with app			
	Proposition with app	1		
	Structure with app	1		
	Arguments without app			1
	Conscious about them without app			
	Counter-arguments without app			
	Decision without app			2
	Focus without app			
	General without app			
	Off subject without app			
	Proposition without app			1
	Structure without app	1		2
Decision				
	Content			1
	Dependent on issue			
	Dependent on topic	1	3	
	Depth			
	General	1		
	Influenced by attributes of participants			
	Content with app			
	Dependent on issue with app			
	Dependent on topic with app			
	Depth with app			
	General with app	3		
	Influenced by attributes of participants with app			
	Content without app			
	Dependent on issue without app			
	Dependent on topic without app			
	Depth without app			1
	General without app			1
	Influenced by attributes of participants without app			
Discussion				
	Communication			
	Content			
	Depth			
	Flow	1	1	

	Focus			
	General	1		
	Structure	1		
	Communication with app	1		
	Content with app			
	Depth with app			
	Flow with app	2		
	Focus with app	2		
	General with app	2		
	Structure with app	4		
	Communication without app			
	Content without app			
	Depth without app			
	Flow without app	1		
	Focus without app	2		1
	General without app	1		
	Structure without app			4
Group				
	Attributes of participants			
	Dynamic			
	Participant contribution			1
Setting				
	General			
	Recording		1	
	Time			1
Topic				
	Content of topic bike		1	3
	Content of topic website		1	
	Depth			
	Focus			
	General		2	
	Influenced by attributes of participants		1	

Table 21

Group 5: Session one – without app – website

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence			
	Use			
Cognitive load				
	No secondary task			
	Secondary task			
	Secondary task other than app			
Communicational aspects				
	Arguments	2		
	Conscious about them			
	Counter-arguments		1	2
	Decision			
	Focus			
	General			
	Off subject			
	Proposition		1	
	Structure	1	1	
Decision				
	Content	4		
	Dependent on issue			
	Dependent on topic			
	Depth			
	General	3		
	Influenced by attributes of participants			
Discussion				
	Communication			
	Content	1		
	Depth		1	1
	Flow			
	Focus	3		1
	General	3		
	Structure	4		4
Group				
	Attributes of participants			
	Dynamic	2	1	
	Participant contribution	1		
Setting				
	General		1	
	Recording			
	Time		1	

Topic				
	Content of topic bike			
	Content of topic website	1		
	Depth			
	Focus	1		
	General			
	Influenced by attributes of participants			

Table 22

Group 5: Session two – with app – bicycle parking

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence	2	1	
	Use	1		2
Cognitive load				
	No secondary task			
	Secondary task		1	5
	Secondary task other than app			
Communicational aspects				
	Arguments	1		1
	Conscious about them	7	1	
	Counter-arguments	1		2
	Decision	5		1
	Focus	1		
	General			
	Off subject	1		
	Proposition			1
	Structure	2	1	
Decision				
	Content	1		
	Dependent on issue			
	Dependent on topic			
	Depth			
	General	4		
	Influenced by attributes of participants			
Discussion				
	Communication	2		
	Content	1		
	Depth	1		1
	Flow			1
	Focus	2	1	3

	General	2	1	
	Structure	7	2	2
Group				
	Attributes of participants			
	Dynamic	3		
	Participant contribution	1	1	
Setting				
	General			
	Recording			
	Time		1	
Topic				
	Content of topic bike			
	Content of topic website			
	Depth			
	Focus			
	General			
	Influenced by attributes of participants			

Table 23

Group 5: Comparison

Sensitizing concept	***Theme-codes***	***Variation codes***		
		positive	*neutral*	*negative*
App				
	Expectations			
	General influence	3		
	Use	1		
Cognitive load				
	No secondary task			
	Secondary task	1		1
	Secondary task other than app			
Communicational aspects				
	Arguments			
	Conscious about them			
	Counter-arguments			
	Decision	2		
	Focus			
	General			
	Off subject			
	Proposition			
	Structure			
	Arguments with app			
	Conscious about them with app	2		
	Counter-arguments with app			

	Decision with app	2	
	Focus with app		
	General with app		
	Off subject with app		
	Proposition with app		
	Structure with app	3	
	Arguments without app		
	Conscious about them without app		
	Counter-arguments without app		
	Decision without app		
	Focus without app		
	General without app		
	Off subject without app		
	Proposition without app		
	Structure without app		
Decision			
	Content		
	Dependent on issue		
	Dependent on topic		4
	Depth		
	General		
	Influenced by attributes of participants		
	Content with app		
	Dependent on issue with app		
	Dependent on topic with app		
	Depth with app	1	
	General with app		
	Influenced by attributes of participants with app		
	Content without app		
	Dependent on issue without app		
	Dependent on topic without app		
	Depth without app		
	General without app		
	Influenced by attributes of participants without app		
Discussion			
	Communication		
	Content		1
	Depth		
	Flow	2	
	Focus		

	General		
	Structure	1	1
	Communication with app		
	Content with app		
	Depth with app	1	
	Flow with app	2	
	Focus with app	1	
	General with app		
	Structure with app	2	
	Communication without app		
	Content without app		
	Depth without app		
	Flow without app		
	Focus without app		
	General without app		
	Structure without app		
Group			
	Attributes of participants		
	Dynamic	4	
	Participant contribution		
Setting			
	General	1	
	Recording		
	Time		
Topic			
	Content of topic bike		
	Content of topic website		
	Depth		
	Focus		
	General		
	Influenced by attributes of participants		

12.13. Appendix 13: Encoding scheme interviews

Table 24

Encoding scheme interviews

Sensitizing concept	***Theme-code***	***Variation-code***
App	Expectations, General Influence, Use	Positive, Negative, Neutral
Cognitive load	No secondary task, Secondary task, Secondary task other than app	Positive, Negative, Neutral
Communicational aspects	Arguments, Conscious about them, Counter-arguments, Decision, Focus, General, Off Subject, Proposition, Structure	Positive, Negative, Neutral
Decision	Content, Dependent on issue, Dependent on topic, Depth, General, Influenced by attributes of participants	Positive, Negative, Neutral
Discussion	Communication, Content, Depth, Flow, Focus, General, Structure	Positive, Negative, Neutral
Group	Attributes of participants, Dynamic, Participant contribution	Positive, Negative, Neutral/Different
Setting	General, Recording, Time	Positive, Negative, Neutral/Different
Topic	Content of the topic bike, Content of the topic Website, Depth, Focus, Influenced by attributes of participants	Positive/Easy, Negative/Difficult, Neutral/Different

12.14. Appendix 14: Summary codes

Table 25

Results: Sensitizing concept Discussion

			Communication	***Content***	***Depth***	***Flow***	***Focus***	***General***	***Structure***
Group 2	*With app*	*Positive*	3		1		3		4
		Negative	2		3	6	9	1	11
	Without app	*Positive*	4	2	1	6	7	3	1
		negative			1		3	1	7
Group 3	*With app*	*Positive*	4	1	1	3	12	4	12
		Negative	1			1	1	1	
	Without app	*Positive*					3	5	1
		negative	1				5		3
Group 4	*With app*	*Positive*	6			2	8	5	10
		Negative	1	1		5	2		5
	Without app	*Positive*	1			3	2	3	3
		negative	1	3	1	1	3		8
Group 5	*With app*	*Positive*	2	1	2	2	3	2	9
		Negative			1	1	3		2
	Without app	*Positive*		1			3	3	4
		negative			1		1		4

Table 26

Results: Sensitizing concept Communicational aspects

			Arguments	***Conscious about them***	***Counter-arguments***	***Decision***	***Focus***	***General***	***Off subject***	***Proposition***	***Structure***
Group 2	*With app*	Positive	1	3	2		2			2	
		Negative	2			1	3		1	1	4
	Without app	Positive									
		negative		3	1		1			1	1
Group 3	*With app*	Positive	1	11	2	2	7		1	1	4
		Negative		2							
	Without app	Positive	1	1							
		Negative			1				1		2
Group 4	*With app*	Positive	2	11		3	3		1	4	5
		Negative	1		2		2				1
	Without app	Positive		1							2
		Negative	1	1		2	1		1	1	2
Group 5	*With app*	Positive	1	9	1	7	1		1		5
		Negative	1		2	1				1	
	Without app	Positive	2								1
		Negative			2						

Table 27

Results: Sensitizing concept Decisions

			Content	***Depth***	***General***
Group 2	*With app*	Positive	2	1	4
		Negative	2	2	2
	Without app	Positive	2	2	3
		Negative			
Group 3	*With app*	Positive		2	6
		Negative	2		1
	Without app	Positive	1		5
		Negative		2	2
Group 4	*With app*	Positive			6
		Negative			
	Without app	Positive			2
		Negative	2	4	4
Group 5	*With app*	Positive	1	1	4
		Negative			
	Without app	Positive	4		3
		negative			

Table 28

Results: Sensitizing concept Cognitive load

		No secondary task	***Secondary task***	***Secondary task other than app***
Group 2	*Positive*	7	1	
	Negative		13	
Group 3	*Positive*		2	2
	Negative		6	
Group 4	*Positive*	3		
	Negative		6	1
Group 5	*Positive*		1	
	Negative		6	

Table 29

Results: Sensitizing concept App

		Expectations	***General influence***	***Use***
Group 2	*Positive*		1	1
	Negative		1	2
Group 3	*Positive*		1	3
	Negative	2		1
Group 4	*Positive*		9	2
	Negative			2
Group 5	*Positive*		5	2
	Negative			2

Table 30

Results: Sensitizing concept Topic

		Content of topic "bicycle"	***Content of topic "website"***
Group 2	*Positive*	1	4
	Negative	4	1
Group 3	*Positive*		4
	Negative	4	
Group 4	*Positive*		1
	Negative	7	3
Group 5	*Positive*		1
	Negative		

Table 31

Results: Sensitizing concept Group

		Attributes of participants	*Dynamic*	*Participants contribution*
Group 2	Positive		2	
	Negative		5	
Group 3	Positive		6	2
	Negative		8	3
Group 4	Positive		7	2
	Negative		4	4
Group 5	Positive		9	2
	Negative			

Table 32

Results: Sensitizing concept Setting

		General	***Recording***	***Time***
Group 2	*Positive*			
	Negative	5	2	1
Group 3	*Positive*			
	Negative	1	1	1
Group 4	*Positive*			
	Negative			5
Group 5	*Positive*	1		
	Negative			

12.15. Appendix 15: Descriptive statistics

Table 33 and Table 34

Descriptive statistics: Discussion

	Condition*	***Mean***	***Median***	***Range***	***SD***
Communication	1	3.75	3.5	4	1.708
	2	1.00	1.0	2	.816
	3	1.25	.5	4	1.893
	4	.50	.5	1	.577
Content	1	.50	.5	1	.577
	2	.25	.0	1	.500
	3	.75	.5	2	.957
	4	.75	.0	3	1.500
Depth	1	1.00	1.0	2	.816
	2	1.00	.5	3	1.414
	3	.25	.0	1	.500
	4	.75	1.0	1	.500
Flow	1	1.75	2.0	3	1.258
	2	3.25	3.0	5	2.630
	3	2.25	1.5	6	2.872
	4	.25	.0	1	.500
Focus	1	6.50	5.5	9	4.359
	2	3.75	2.5	8	3.594
	3	3.75	3.0	5	2.217
	4	3.00	3.0	4	1.633
General	1	2.75	3.0	5	2.217
	2	.50	.5	1	.577
	3	3.50	3.0	2	1.000
	4	.25	.0	1	.500
Structure	1	8.75	9.5	8	3.403
	2	4.50	3.5	11	4.796
	3	2.25	2.0	3	1.500
	4	5.50	5.5	5	2.380

**1 = with app – positive; 2 = with app – negative; 3 = without app – positive; 4 = without app - negative*

Descriptive statistics: Communicational aspects

	*Condition**	*Mean*	*Median*	*Range*	*SD*
Arguments	1	1.25	1.0	1	.500
	2	1.00	1.0	2	.816
	3	.75	.5	2	.957
	4	.25	.0	1	.500
Conscious about them	1	8.50	10.0	8	3.786
	2	.50	.0	2	1.000
	3	.50	.5	1	.577
	4	1.00	.5	3	1.414
Counter-arguments	1	1.25	1.5	2	.957
	2	1.00	1.0	2	1.155
	3	.00	.0	0	.000
	4	1.00	1.0	2	.816
Decision	1	3.00	2.5	7	2.944
	2	.50	.5	1	.577
	3	.00	.0	0	.000
	4	.50	.0	2	1.000
Focus	1	3.25	2.5	6	2.630
	2	1.25	1.0	3	1.500
	3	.00	.0	0	.000
	4	.50	.5	1	.577
General	1	.00	.0	0	.000
	2	.00	.0	0	.000
	3	.00	.0	0	.000
	4	.00	.0	0	.000
Off subject	1	.75	1.0	1	.500
	2	.25	.0	1	.500
	3	.00	.0	0	.000
	4	.50	.5	1	.577
Proposition	1	1.75	1.5	4	1.708
	2	.50	.5	1	.577
	3	.00	.0	0	.000
	4	.50	.5	1	.577
Structure	1	3.50	4.5	5	2.380
	2	1.25	.5	4	1.893
	3	.75	.5	2	.957
	4	1.25	1.5	2	.957

**1 = with app – positive; 2 = with app – negative; 3 = without app – positive; 4 = without app - negative*

Table 35

Descriptive statistics: Communicational aspects

	Condition*	***N***	***Mean***	***Median***	***Range***	***SD***
Total	1	118	14.75	11.0	27	11.184
	2	30	3.75	3.0	9	2.915
	3	93	23.25	27.0	19	9.032
	4	25	6.25	5.5	10	4.193
	5	8	2.00	2.0	3	1.414
	6	22	5.50	5.5	7	3.109

**1 = with app; 2 = without app; 3 = with app – positive; 4 = with app – negative; 5 = without app – positive; 6 =without app – negative;*

Table 36

Descriptive statistics: Decision

	Condition*	***Mean***	***Median***	***Range***	***SD***
Content	1	.75	.5	2	.957
	2	1.00	1.0	2	1.155
	3	1.75	1.5	4	1.708
	4	.50	.0	2	1.000
Depth	1	1.00	1.00	2	.816
	2	.50	.0	2	1.000
	3	.50	.0	2	1.000
	4	1.50	1.0	4	1.915
General	1	5.00	5.0	2	1.155
	2	.75	.5	2	.957
	3	3.25	3.0	3	1.258
	4	1.50	1.0	4	1.915

**1 = with app – positive; 2 = with app – negative; 3 = without app – positive; 4 = without app - negative*

Table 37

Descriptive statistics: Cognitive load

	Condition*	***Mean***	***Median***	***Range***	***SD***
No secondary task	1	2.50	1.5	7	3.317
	2	.00	.0	0	.000
Secondary task	1	1.00	1.0	2	.816
	2	7.75	6.0	7	3.500
Secondary task other than app	1	.50	.0	2	1.000
	2	.25	.0	1	.500

**1 = positive; 2 = negative;*

Table 38

Descriptive statistics: App

	Condition*	***Mean***	***Median***	***Range***	***SD***
Expectation	1	.00	.0	0	.000
	2	.50	.0	2	1.000
General influence	1	4.00	3.0	8	3.830
	2	.25	.0	1	.500
Use	1	2.00	2.0	2	.816
	2	1.75	2.0	1	.500

**1 = positive; 2 = negative;*

Table 39

Descriptive statistics: Topic

	Condition*	***Mean***	***Median***	***Range***	***SD***
Content "bicycle parking"	1	.25	.0	1	.500
	2	3.75	4.0	7	2.872
Content "website"	1	2.50	2.5	3	1.732
	2	1.00	.5	3	1.414

**1 = positive; 2 = negative;*

Table 40

Descriptive statistics: Group

	Condition*	***Mean***	***Median***	***Range***	***SD***
Attributes of participants	1	.00	.0	0	.000
	2	.00	.0	.0	.000
Dynamic	1	6.00	6.0	7	2.944
	2	4.25	4.5	8	3.304
Participants contribution	1	1.50	2.0	2	1.000
	2	1.75	1.5	4	2.062

**1 = positive; 2 = negative;*

Table 41

Descriptive statistics: Setting

	Condition*	***Mean***	***Median***	***Range***	***SD***
General	1	.25	.0	1	.500
	2	1.5	.5	5	2.380
Recording	1	.00	.0	0	.000
	2	.75	.5	2	.957
Time	1	.00	.0	0	.000
	2	2.00	1.5	5	2.160

**1 = positive; 2 = negative;*

12.16. Appendix 16: Tables statistical comparison

Table 42

Comparison (Mann-Whitney U): Discussion

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
Communication	1	-1.607	.108
	2	-.949	.343
	3	-2.191	.028
	4	-.316	.752
Content	1	-.316	.752
	2	-.189	.850
	3	-.683	.495
	4	-.331	.741
Depth	1	-1.423	.155
	2	-.158	.874
	3	-.303	.762
	4	-1.323	.186
Flow	1	-.150	.881
	2	-2.124	.034
	3	-.584	.559
	4	-.992	.321
Focus	1	-1.230	.219
	2	-.149	.882
	3	-1.183	.237
	4	-.308	.758
General	1	-.477	.655
	2	-.683	.495
	3	-1.488	.137
	4	-2.428	.015
Structure	1	-2.191	.028
	2	-.577	.564
	3	-1.155	.248
	4	-1.764	.078

**1 = comparison with app positive – without app positive; 2 = with app negative – without app negative; 3 = comparison with app positive – with app negative; 4 = comparison without app positive – without app negative*

Table 43

Comparison (Mann-Whitney U): Communicational aspects

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
Arguments	1	-.935	.350
	2	-1.423	.155
	3	-.500	.617
	4	-.833	.405
Conscious about them	1	-2.352	.019
	2	-.661	.508
	3	-2.381	.017
	4	-.316	.752
Counter-arguments	1	-2.000	.046
	2	.000	1.000
	3	-3.16	.752
	4	-2.000	.046
Decisions	1	-1.984	.047
	2	-.333	.739
	3	-1.488	.137
	4	-1.000	.317
Focus	1	-2.460	.014
	2	-.619	.536
	3	-1.176	.240
	4	-1.528	.127
Off subject	1	-2.049	.040
	2	-.683	.495
	3	-1.323	.186
	4	-1.528	.127
Propositions	1	-1.984	.047
	2	.000	1.000
	3	-1.214	.225
	4	-1.528	.127
Structure	1	-1.488	.137
	2	-.449	.653
	3	-1.348	.178
	4	-.764	.445

**1 = comparison with app positive – without app positive; 2 = with app negative – without app negative; 3 = comparison with app positive – with app negative; 4 = comparison without app positive – without app negative*

Table 44

Comparison (Mann-Whitney U): Decision

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
Content	1	-.899	.369
	2	-.683	.495
	3	-.316	.752
	4	-1.239	.215
Depth	1	-.935	.350
	2	-.833	.405
	3	-.935	.350
	4	-.833	.405
General	1	-1.764	.078
	2	-.464	.642
	3	-2.352	.019
	4	-1.323	.186

**1 = comparison with app positive – without app positive; 2 = with app negative – without app negative; 3 = comparison with app positive – with app negative; 4 = comparison without app positive – without app negative*

Table 45

Comparison (Mann-Whitney U): Cognitive load

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
No secondary task	1	-1.512	.131
Secondary task	1	-2.381	.017
Secondary task other than app	1	-.189	.850

**1 = comparison positive - negative*

Table 46

Comparison (Mann-Whitney U): App

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
Expectations	1	-1.000	.317
General influence	1	-2.124	.034
Use	1	-.500	.617

**1 = comparison positive - negative*

Table 47

Comparison (Mann-Whitney U): Topic

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
Content "bicycle parking"	1	-1.703	.089
Content "website"	1	-1.498	.134

**1 = comparison positive - negative*

Table 48

Comparison (Wilcoxon Signed Ranks): Topic

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
Positive	1	-1.841	.066
Negative	1	-1.633	.102

**1 = comparison topic "website" – topic "bicycle parking"*

Table 49

Comparison (Mann-Whitney U): Group

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
Dynamic	1	.000	1.000
Participant contribution	1	-.607	.544

**1 = comparison positive - negative*

Table 50

Comparison (Mann-Whitney U): Setting

	Condition*	**Z**	**Asymp. Sig. (2-tailed)**
General	1	-.833	.405
Recording	1	-1.512	.131
Time	1	.000	1.000

**1 = comparison positive - negative*