Bachelor's Thesis:

Conceptual Blending of Dialog and Image Schema - Design and Pilot Test of an Image-Schematically Metaphoric Collaborative Decision-Making Tool

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Abstract

Collaborative Decision-Making Technologies are Ontology Softwares that support knowledge management by structuring and visualizing the collaborative dialog via a flexible user interface. In favor of enhancing such interfaces' practicality, a range of possibilities which is yet to be explored is offered by image schemas. Since Image schemas are considered to be fundamental to all humans' cognition on several levels, it is assumed that image-schematic metaphors can be applied in interface design in order to make them universally more intuitive and representative of the CDM process. The guiding interest of this thesis is the question to which extent conceptual notions of image schemas on the one hand, and of the collaborative dialog on the other hand should be blended when designing the visual interface. Therefore, the main constituent of this thesis is the conceptualization of an Image-Schematically Metaphoric Collaborative Decision-Making (ISMCDM) Tool. Based on a framework of grounded theory synthesized, the visual interface expresses image-schematic metaphors in its visual design, while its ontological categorization of contributions to the CDM process is partly derived from the Issue-Based Information System (IBIS). As a first attempt to investigate the effect on applying a composition of image schemas in the CDM Tool as blended space, a pilot study is conducted in order test a CDM Tools most prominent qualities. For this, an experimental between-groups design is employed. One group of human research subjects gets to observe a fictional case of a CDM process, as the ISMCDM Tool would gradually map it. The same case is presented to a control group of subjects, but in the in a form of a fictional CDM Tool that resembles a mind map. Knowledge retrieval from and user experience of the respective representation are assessed among all participants and compared among the two groups. As hypothesized, the knowledge retrieval is significantly higher among participants presented with the ISMCDM Tool. Unlike hypothesized secondly, no significant difference was found between the groups regarding user experience. However, it is refrained from drawing concrete conclusions from these results regarding the optimal extent of application of image schemas in a blended space. Instead, recommendations for future research of mostly qualitative methodology shall investigate the interplay between single specific design aspects of the blended space and attributes individual to the user.

Keywords: Ontology, Collaborative Decision-Making, Conceptual Blending, Image-Schema, Image-Schematic Metaphor, Knowledge Management, Information Visualization

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1. INTRODUCTION

Along with the increasing abundance and complexity of information gathered and knowledge created in several contexts mankind acts and operates in, whether that be science, journalism, bureaucracy economy, the chances for the manifestation of obstacles in our channels of communication grow accordingly. More often than not, at the root of an action with consequences considered to be negative or suboptimal lies a decision based on hindered communication.

Despite any form such hindrances can take, the aim of successful communication in favor of picking the best option possible remains the same, as being its very essence. It is a consensual awareness of all information concerned with, and by all parties concerned. The process of different parties or human individuals exchanging knowledge and ideas, and consequently picking options yielded by these, is referred to as Collaborative Decision-Making (CDM). Attempts of supporting successful CDM in face of obstacles related to distance, time and the information communicated itself, have been made in the development of technology, specifically computer softwares operating via visual interfaces.

Two main ways of how CDM technologies function can be named. Firstly, the collaborative dialog is structured by giving the user of the CDM software a set of pre-categorized possible options to contribute to the dialog. The second main function is representing these contributions visually on the computer screen, so that the user gets a dynamic and flexible overview of the CDM process' structure.

Although such technologies appear to be promising means for CDM, there is more potential to be tapped. For the most part, CDM tools don't manage to be of more practicality than they might be due to the fact that their ways of structuring and representing the CDM process are not as in line with our actual human perception of them to the extent they could possibly be. The primary aim in interest of CDM technologies' very purpose of communicating information, therefore, is to align their visual design with the actual our way of perceiving CDM process, its structure and its qualitative aspects.

A promising range of possibilities to do so appears to be offered by Image Schemas. Image schemas are cognitive patterns that are built on years of sensorimotor experience and therefore profoundly direct our ways of perceiving the world and organizing our thoughts and conceptualizations. References to such building blocks of the mind, called Image-Schematic Metaphors, can be made by visually implying them the CDM interface's design, with the aim of creating a correspondence between the representation of the CDM process and our mental model of it which shall result in more practicality.

It would be interesting to investigate which image-schematic metaphors, and in which way they are applied in the CDM Tool's visual interface, optimally result in such a correspondence. Therefore, a theoretical framework will set revolving around which image schemas appear most appropriate for the expression in visual design in the context of CDM. Based on this framework, an image-schematically metaphoric CDM system and interface will be designed. The creation of a theoretical framework based on implications derived from scientific literature and the design of the CDM tools as the main constituents of this thesis.

Secondarily, a pilot test of the tool will will conducted in order to aspire towards the investigation of overarching principles regarding the application of image-schematic metaphors for optimal practicality and intuitiveness. In favor of this, the image-schematically metaphoric CDM tool is tested for two qualities considered to be essential for any CDM tool, namely retrieval of knowledge from the visual representation presented by the interface, and subjective user experience of it.

2. THEORETICAL FRAMEWORK

2.1 Ontologies and Collaborative Decision-Making

For collaborating parties within several modern consensuses, whether scientific, journalistic or organizational, problems commonly faced during communication are physical distance, temporal delay and overall complexity and consequent general bias (Iandoli, Quinto, De Liddo, & Buckingham Shum, 2014). Deliberation of such complications of successful Collaborative Decision-Making necessitates overall guidance, clear structuring as well as representational manifestation of the collaborative dialog. Fulfillment of these necessities is sought in the development and use of ontology softwares as CDM tools. Ontology softwares organize knowledge and information as a structured set of interrelated entities.

In the context of CDM technologies, the application of ontologies incorporates an approach that Iandoli et al. (2014) call Collaborative Computer-Supported Argument Visualization (CCSAV). In this approach, elements of the CDM process and their interrelations are represented in a flexible, visual user interface. Users have the possibility to contribute to the collaborative dialog, and thus modify its representation, by choosing between predetermined elements of the dialog and stating their specific meaning. Besides information management, such tools are even claimed to facilitate critical, reflected and creative thinking (Iandoli et al., 2014.)

One example of such an ontology is the Issue-Based Information System (IBIS), which organizes and visualizes Issues, Propositions and Arguments in a hierarchical fashion (Lopez, Cysneiros, & Astudillo, 2008). It is an established system made use of by multiple softwares, such as Compendium (http://www.compendiuminstitute.net/about.htm). Another example of a tool supporting collective dialog is Kialo (https://www.kialo.com/), which organizes statements within discussions as hierarchies consisting of opposing elements. Lastly, mind maps and concept maps form a notable example of what can be considered ontological means of knowledge management, since they structure and visualize entities of information and clarify their interrelations (Beel, Gipp, & Stiller, 2009).

Essential to a ontology software's visual interface is the degree of representativeness of information displayed. High representativeness can be attained when some form of analogy is established between between source and goal domain (Morrison & Morgan, 1999), i.e. a correspondence of elements structured by the ontology and structural elements of the actual information that shall be represented by it. For a CDM software, representativeness means that the nature and quality of elements displayed by its interface resemble the nature and quality of the CDM process mapped.

A further key aspect of a CDM tool's overall fidelity and practicality is the extent of intuitiveness experienced during use. Intuitive use can be defined as the ‚extent to which a product can be used by subconsciously applying prior knowledge, resulting in an effective and satisfying interaction using a minimum of cognitive resources' (Hurtienne, 2011, p. 29).

2.2 Expressing Image Schemas in Ontologies

A way of attaining representativeness in the sense of above definition, as well as experienced intuitiveness through activation of prior knowledge within Human-Computer Interaction (HCI) is by exploiting the nature of image schemas (Hurtienne, 2017). From these ‚first building blocks of the mind', as Hurtienne (2017) defines them, image-schematic metaphors are naturally derived into several domains humans operate in, among which the cognitive and the linguistic. This leads to the assumption that image-schematic metaphors are excellent for the application in the representational design of ontology softwares.

Hurtienne (2017) refers to and elaborates on the notion of Conceptual Blending, which is incorporating elements from different domains into the design of the blended space, in this case the CDM interface. In the design of a CDM interface, one concrete example of blending qualitative elements of an actual CDM process with elements of the image-schematically metaphorical domain would be visualizing an issue of the dialog as a hollow or open shape. The hollowness or openness of a shape lacking filling or closure would signify the lacking of communication revolving around or clarification of the issue. While the usefulness of blending theory has been demonstrated by several designs, as Hurtienne (2017) states, concrete compositional aspects of the different domains' elements blended haven't been established.

It would be interesting to investigate the extent to which image-schematic metaphors should be present within the blended space of ontology software for overall optimal use. In respect of this interest, the main part of this research is the conceptualization of an Image-

Schematically Metaphoric Collaborative Decision Making (ISMCDM) Tool. As its name implies, it is an ontology software for discussion, collaborative dialog and decision making whose visual interface design employs image-schematic metaphors.

2.3 Image Schemas Appropriate for CDM Interfaces

A range of image-schematic metaphors can been derived from scientific literature that appear appropriate the application in a CDM tool, in the sense that an analogy between the ontological representation and the actual collaborative dialog including its qualitative nature, as elaborated on above, can be maintained consistently.

One key image schema for the design of an ontology interface is CENTER - PERIPHERY. Formed upon the perception of our human physical embodiment, not only objects can be more or less central or peripheral to us, but also can matters of different relevance or priority appear of different distance to us (Johnson, 1987). This image-schematic metaphor of subordinate elements are assigned towards the CENTER and superordinate elements aligning towards the PERIPHERY is expressed e.g. in taxonomies and and mind maps.

Similarly important for the application in the context of ontologies is the image schema group CONTAINMENT. According to Johnson (1987), conceptions of CONTAINMENTS of CONTENT within CONTAINERS are commonly superimposed upon conceptualizations of CENTER and PERIPHERY. Within a visual ontology, subordinate elements of information can take the form of CONTENT, while superordinate elements are their CONTAINERS.

Another image schema adequate for indicating properties underlying to elements within collaborative dialog, such as e.g. relevance or quantity, is UP - DOWN. Several contexts and everyday situations of our human life have taught the profound and universal persuasion that MORE IS UP and LESS IS DOWN, as stated by Johnson (1987) and Hurtienne (2017). Similarly, this metaphor is reflected on the property of size; elements of a bigger size can indicate higher relevance than smaller elements.

In addition to the aspect of analogy, above image schemas are the origins of what Mandler (2014) and Hurtienne (2017) call primitive metaphors, which are conceptualizations of multi-modal nature that precede a human individual's development of language and reasoning. They are therefore seen as especially relevant when it comes to the design of an ontological structure which is supposed to express design aspects that are universally understood.

Besides these primary metaphors, some image-schematic metaphors are founded on what Mandler (2014) calls schematic integration. Hereby, attributes that are of another perceptual nature than e.g. spatial, are projected onto image schemas. A specific example of such conceptual representation is HEAVY - LIGHT, listed in the image schema group ATTRIBUTE by Hurtienne (2008). In the context of a CDM software, the attribute HEAVY can be associated with an element's informative value, gravity, expressiveness, necessity, etc.

Another aspect requiring metaphorical representation within a CDM interface is recency of information. Due to the dynamic nature of collaborative dialog, a chronological structure has to be implied by its design. The main guideline for this aspect is the conceptual metaphor TIME GOES FROM LEFT TO RIGHT (Santiago, Román, Quellet, Rodríguez, & Pérez-Azor, 2010, as referred to by Mandler, 2014). While not certainly of image-schematic origin, as discussed in below sections of this thesis, it is still a widespread implication expressed in written text as well as clockwise rotation in Western cultures.

3. DESIGN OF THE ISMCDM TOOL

The Image-Schematically Metaphoric Collaborative Decision Making (ISMCSM) Tool is thought of as a browser based web application. Similar to an online discussion board, users of the tool have individual accounts and can contribute to the CDM process when access to a particular CDM process is granted via online invitation. The tool helps structuring and guiding the CDM process on the one hand, and visually representing the CDM process' structure on the other.

Guidance and structuring is provided by the tool's general function of contributing to the CDM process, as well as by a set of rules, as elaborated below. Users of the tool are able to contribute by choosing between five different elements, namely *Issues*, *Propositions*, *Arguments*, *Counterarguments* and *Doubting Arguments*, and simultaneously textually formulating the actual meaning of the particular contribution made, i.e. element placed. This ontological categorization of contributions into five different elements was partly derived from the IBIS' way of functioning (https://eight2late.wordpress.com/category/issue-based-information-system/), which also Compendium makes use of, partly from own subjective intuition concerning practical use in this specific context and in regard of the application of image-schematic metaphors. When chosen, these elements are displayed as single shapes of different form and color on the tool's interface. Throughout its progress, the CDM process is mapped in a hierarchical arrangement of these elements. Users shall be able to inspect single elements of the mapped CDM process. By hovering over particular shapes with the mouse cursor, information of the respective element, i.e. the actual content, the name of the user who placed this element, etc., pops up in a text window.

At the bottom of the interface a solid field is displayed that represents the main topic or objective of the CDM progress/the discussion. From there on, all subordinate elements, i.e. *Issues*, *Propositions*, *Arguments*, *Counterarguments* and *Doubting Arguments*, line up in an upward direction. This resembles the human visual field. The topic as a base is therefore by something depicting a floor, while the elements based on the topic rest above it, like physical objects piled up rest on top of each other due to gravitational force. This he hierarchical setup of the elements corresponds with the image schema CENTER - PERIPHERY (Hurtienne, 2008).

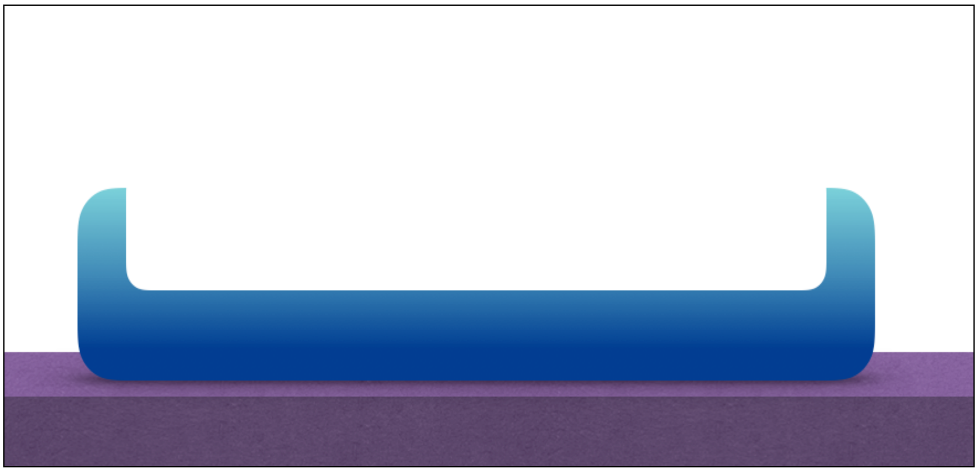

Figure 1. An *Issue* shape resting on the floor symbolizing the topic.

Issues are questions or subitems of the overarching topic of whatever dialog, discussion or collaborative task shall be mapped by the ISMCDM tool, and can be placed freely, without restrictions. Due to the nature of *Issues* as being subordinate elements of a topic they are displayed as rectangular shapes resting above the floor-like field symbolizing the topic (Figure 1). The left and right edge are depicted as verges, indicating the image-schema CONTAINMENT (Hurtienne, 2008). Most recent and current *Issues* tend to be indicated on the right screen side. The horizontal axis therefore represents a timeline and accords to the conceptual metaphor TIME GOES FROM LEFT TO RIGHT (Mandler, 2014).

Propositions are formulated in regard of Issues. Because of being a subordinate element to Issues within the informal structure provided by the ISMCDM system, subject to CONTAINMENT by *Issues*, the shapes representing *Propositions*, are arranged on top of the *Issue*-shape, between its verges. For giving form to *Propositions*, including their different kinds of arguments, again the image schema group CONTAINMENT listed by Hurtienne (2008) is most prominently made use of. *Propositions* are given the shape similar to the letter ‚U', resembling the vertical intersection of a CONTAINER (Figure 2). Its CONTENT, i.e. *Arguments* and *Counterarguments* regarding the *Proposition* are displayed as rounded rectangles within it. A general rule is that a *Proposition* always has to formulated as an affirmative statement. The primary reason for this is that the informal structure of *Arguments* as statements in favor of, and *Counterarguments* as statements against the meaning of the respective *Proposition* is maintained. A practical side effect might be that users are less tempted to formulate negative propositions and therefore make more reflected and constructive contributions to the CDM process.

Figure 2. Shape symbolizing a *Proposition.*

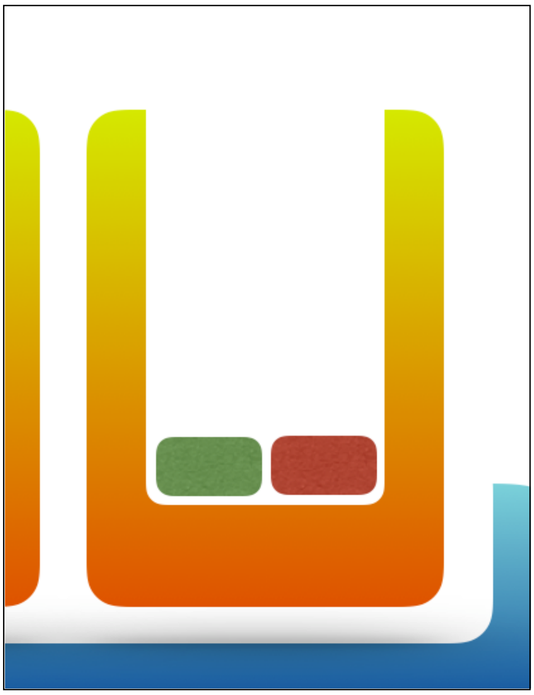

Figure 3. An *Argument* opposing a *Counterargument.*

Arguments are statements in favor of a *Proposition*. When an *Argument* is chosen contribute to the CDM process, it appears as a green rectangle at the left lower inner corner of the *Proposition*. New *Arguments* placed line up vertically above, and horizontally on the same level as the *Argument* previously placed. When a *Counterargument* is used to counter a specific *Argument,* it is arranged on the right side next to it on the same height of the vertical axis. When a *Counterargument* is formulated against the implication made by the *Proposition* itself, it acquires space on an own vertical level. Consequently, a new *Argument* in favor of the *Proposition* can be formulated against such a *Counterargument*. This *Argument* would respectively be placed left besides the respective *Counterargument* (Figure 3). The choice of the colors red and green assigned to *Arguments* and *Counterarguments* was was based on widespread negative connotation of the color red, and the contrastingly positive connotation of the color green (Pietrowski, 2013). It is applied in an abundance of contexts, such as traffic, marketing and softwares, among which also Kialo and Compendium.

The overall configuration of *Arguments* and *Counterarguments* is the determinant for the color of the *Proposition* which they refer to. It is dynamic in shade and assumes a color gradient shifting from green over yellow and orange to red, depending on the ratio between arguments and counterarguments and indicating in approximately.

Special attention was paid to the question which of either *Arguments* or *Counterarguments* should be piled up on the left side inside the proposition container, and which one on the ride side. Left and right as egocentric coordinates are connoted differently in an abundance of contexts. Not Latin word ‚sinister' not only means ‚left' but also ‚improper, adverse' (http://www.latin-dictionary.net/), while the word ‚right' in English can be used for indicating a relative direction as well as correctness. Furthermore, the oppositeness of these two directions is made use of in describing a spectrum of political perspectives. At the same time, the handedness of the majority of the human population is right-handedness (http://www.rightleftrightwrong.com/what.html). This corresponds with Hurtienne's (2017) description of the nature of image schemas as being formed by repeated sensorimotor experience. It is therefore reasonable to speculate that these connotations are references of image-schematic origin. A contrary implication about which of the elements shall be displayed left and which at the right is made by the metaphor TIME GOES FROM LEFT TO RIGHT, which can be speculated to be of the same origin. Whether or not there is any actual causal relation to these specific expressions, it would be similarly reasonable to either decide to display counterarguments on the left and arguments on the right, or vice versa. However, the ISMCDM tool's overall flow of functioning implies the preference of the latter option. As described above, a *Proposition* has to be affirmative. Therefore, an *Argument*, being a statement in favor of it, share a higher affinity with the *Proposition*'s original meaning, as well as formulation. This implies an overall higher degree of primacy between the *Argument*

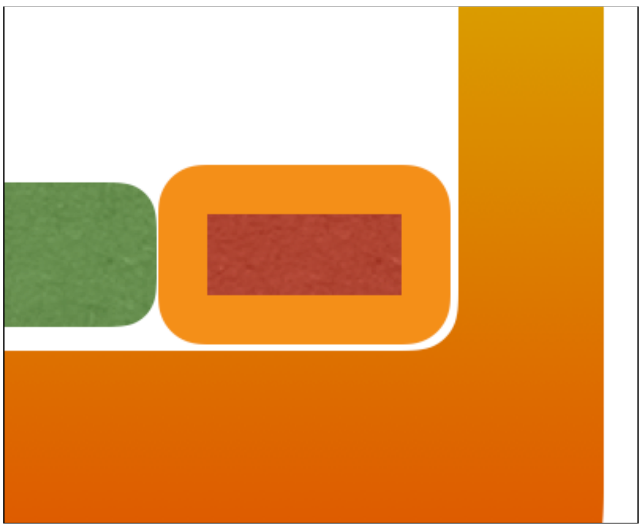

Figure 4. An *Doubting Argument* arranged on a *Counterargument.*

and the *Proposition* at the current stage of the CDM process. Thus, being consequent in relying on the metaphor TIME GOES FROM LEFT TO RIGHT appears to be the overall better option. *Arguments* are therefore displayed on the left, *Counterarguments* on the right side.

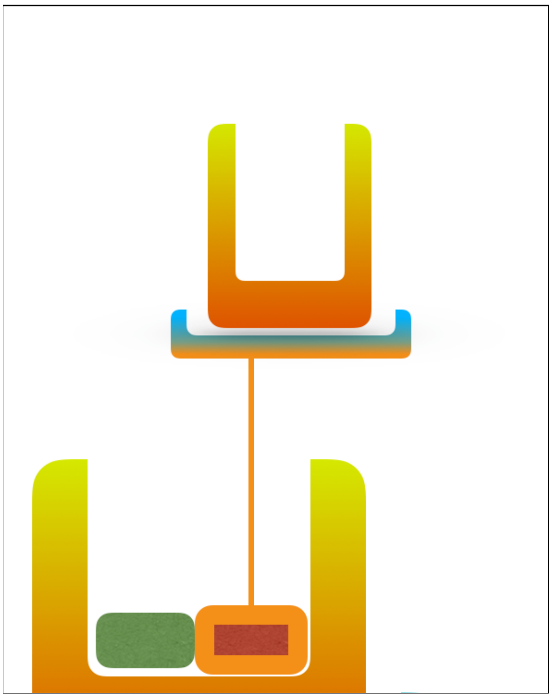

Figure 5. An *Proposition* made regarding an extended *Doubting Argument*

A *Doubting Argument* is displayed as a hollow rectangle arranged onto the respective *Argument* or *Counterargument* and covering the edges (Figure 4). *Doubting arguments* have an orange color to them. Similar to the *Proposition* shape, since it requires further clarification through communication and therefore signifies the image schema EMPTY. On demand of the user, e.g. in the case of a high complexity behind the argument of doubt, the element representing the *Doubting Argument* can be extended towards the periphery of the cluster, i.e. towards the upper side of the screen. It is then displayed as a shape similar to the *Issue*, and connected with the respective argument through a line. New propositions can then be arranged to it (Figure 5). In use of the ISMCDM (as well as in a manner of speaking) it is possible to make an *Issue* out of one's doubt. This helps the interface structure include more of a recursive characteristic.

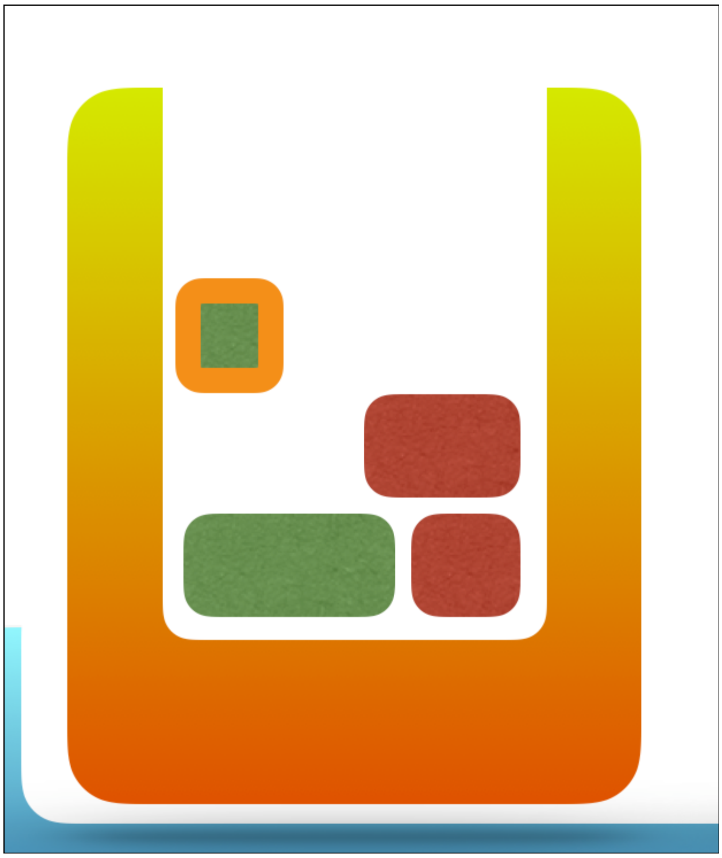

Figure 6. A possible configuration of differently rated elements.

Users are able to rate *Arguments* and *Counterarguments.* With a growing amount of ratings, an *Arguments* or *Counterarguments* grows into the horizontal direction towards the vertical center of the Proposition shape. In the case of an *Argument* and a *Counterargument* opposing each other, i.e. being placed next to each other, the element with the higher rating takes more space, according to the ratio of the two elements' ratings (Figure 6).

All propositions and different sorts of arguments intensify in color according to their significance, that is according to how the quantity of ratings made by the collaborating users certain arguments hold, or how many arguments have been formulated regarding a proposition. This metaphor, indicating the gravity of a proposition or argument, corresponds with the image schema HEAVY - LIGHT (Hurtienne, 2008).

Users can request single *Arguments*, *Counterarguments* and *Doubting Arguments* to be resolved, e.g. in case of low importance or validity, indicated by low ratings. On consent of the majority of other users, the elements then disappear due to resolution. Similarly, requests of formulating a conclusion about the implication of a *Proposition* can be sent. When a common ground among the collaborating parties about a *Proposition* has been found, and the

Figure 7. A *Proposition* for which a conclusion has been formulated.

respective conclusion formulated, the *Proposition's* figurative openness is filled and therefore the before open container is displayed as closed. Additionally, the CONTAINER is displayed in a slightly transparent light blue, signifying LIGHT-ness (Figure 7). The same logical and, accordingly, visual mechanism applies to *Issues*, whose verges enclose the propositions at closure (Figure 8).

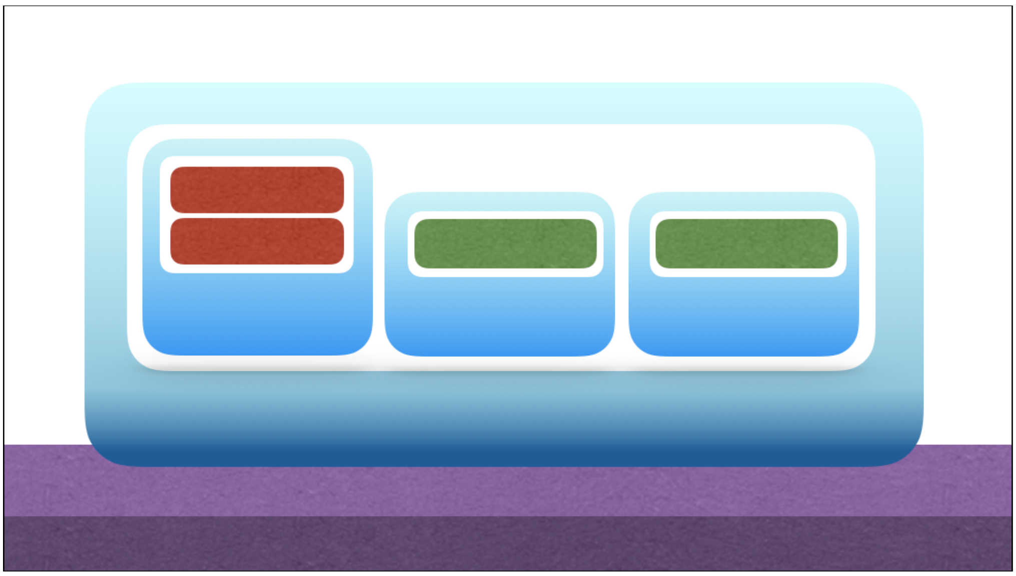

Figure 8. An *Issue* has been settled.

A general aim in displaying the elements is ensuring a certain degree of visual elaborateness. This includes giving the elements, although displayed in a two-dimensional interface, a more three-dimensional look, through the choice of their colors' shades, their shaping, as well as shadowing and accentuation. The primary goal behind this is to highlight image-schemas already applied, namely HEAVY - LIGHT of the image schema group ATTRIBUTE, as well as all image schemas of the group CONTAINMENT, as mentioned by Hurtienne (2008).

A variety of features of the ISMCDM Tool remain which are subject to further specification. They fall beyond the scope of this research, since they are not directly linked to the expression of image-schematic metaphors. Such features, as also listed by Iandoli et al. (2014) are, however, part of the ISMCDM Tool's totality of functions, and therefore necessitated for the tool's actual production, and therefore should be mentioned at least. One aspect is the optimal scaling of the visual elements' size. A second aspect includes functions of the social aspect of the tool, such as user profiles, messaging, notification and updating about the progress of a CDM process. Thirdly, the exact design of ratings of *Arguments* and Counterarguments, as well as of requests for resolutions of certain elements and for formulating conclusions, has to be specified. Other desirable functions are the programming of keyboard shortcuts for placing elements and skipping to other functions, as well as compatibility to other data formats.

4. PILOT STUDY

4.1 Method

Since the main objectives for the conceptualization of the ISMCDM tool are improved practicality and intuitiveness a through were through the application of image-schematic, this thesis includes, next to the design of the ISMCDM Tool, a pilot test of it. The pilot test can be considered an exploratory, experimental between-groups design. In favor of this, the gradual process of a fictional CDM case, as how it would be mapped by the IDMCDM Tool, will be presented to a group of human research subjects. Simultaneously, a control group of subjects will be presented with a stimulus showing the same CDM process, but as it would be represented by another, fictional CDM tool that does not include image-schematic metaphors in its design. All subjects' objective retrieval of information from the stimuli about the CDM process will be assessed by a self-compiled questionnaire, as well as their subjective user experience by a standardized questionnaire. The operationalizations of knowledge retrieval and user experience assessed form two dependent variables as subjects to statistical comparison in regard of the independent variable, i.e. the respective condition of the experiment. Out of this design, the research question can be formulated: Does the application of a composition of image-schematic metaphors in CDM Software result in higher practicality and intuitiveness in terms of knowledge retrieval and user experience? Higher scores on knowledge retrieval as well as on user experience among the experiment group compared to the control group are hypothesized.

4.2 Participants

Since the experiment was conducted in the form of an online survey, participation was open to any possible volunteer with a desktop computer or laptop with internet access and the web link to the Qualtrics survey. One way of reaching participants was via Sona Systems, a cloud-based participant management software made use of by the University of Twente (https://utwente.sona-systems.com). By participating in a study via Sona Systems, Students gain credit points which allow them to finance their own participant search via Sona Systems in later academic years. For another part, gathering participants happened under the procedure of

Convenience Sampling; the Qualtrics web link was sent to members of the researcher's circles of acquaintances. A prerequisite for participation was a rather proficient skill of the English language that would allow understanding of the instruction to the experiment itself, the informed consent form, the textual indications within the stimulus, and for answering the questionnaires, as well as for possibly formulating a comment and/or question to the researcher at the end of the survey. Everybody partook voluntarily and gave informed consent by simply deciding to continue with the experiment after reading the informed consent form at the beginning of the experiment. The limit of 18 years minimum was determined as the legal age for participation, according to the standards of the Ethical Commission. Exclusion criteria were major cognitive or visual impairments,. However, these criteria were somewhat implicit due to the nature of the survey, which required the capability of operating a computer. A total of 70 participants provided data for this research. Out of these, 21 participants had to be excluded after data collection, due to incomplete or obviously contradictory or unreliable responses. Of the remaining 49 participants, 23 were female (46.9%) and 36 were male (53.1%). None of them reported to be of a gender other than female or male. The participants age ranged from 18 to 57 years and averaged out to 24.16 years (*SD* = 9.07). A total of three different countries of origin was counted. 37 of the participants were of German origin (75.5%), 11 of Dutch origin (22.4%), and one of Romanian origin (2.0%). None of the subjects received money or any other form of payment or remuneration for participation, other than Sona credit points, if applicable.

4.3 Materials

Qualtrics (https://www.qualtrics.com) served as a platform for hosting the online survey and enabled gathering data. The Informed Consent statement (Appendix A), the instruction forms of the experiment group (Appendix B) as well as for the control group (C), the actual experiment stimulus (Appendix D) and the control stimulus (Appendix E), a knowledge retrieval questionnaire (Appendix F), a user experience Questionnaire (Appendix G) and a debriefing statement (Appendix H) were all integrated into qualtrics survey and therefore made accessible digitally. The mobile view of the Qualtrics online survey was disabled; it was completed on a laptop or desktop computer by every participant. The presentation program Keynote (Version 6.6.2 (2571)) running on macOS was used for the visual design of the prototypic shapes of the ISMCDM Tool, as well as for the creation of the stimuli for both experimental and control condition.

The stimulus for the experimental condition should mimic the passive use of the ISMCDM Tool, in which participants of the experiment had to watch a CDM process gradually building up as it would be visualized by this tool. This CDM process was a fictional case, and was compiled in the form of a slide show. With each new slide, a new element of the CDM process came into display. The textual meaning of the element simultaneously appeared on the same slide, since a mouse-over function could not be implemented into a regular Qualtrics online Survey. The slide show was then exported to video format with each slide being visible for four seconds and a total length of 280 seconds.

The stimulus for the control condition was conceived as forming a respective contrast to of the ISMCDM Tool regarding the visual design. Its purpose was to represent the CDM case shown in the stimulus for the experimental condition as identically as possible regarding format and content, without applying the composition of image-schematic metaphors used in the ISMCDM Tool. This was attempted by mapping the same CDM process in the form of a regular mindmap. The mind-mapping software iThoughtsX (Version 5.1 (5.1.6358)) was used for this. The textual content, as well as order and arrangement of the elements appearing one at a time with each new slide were identical to those represented in the stimulus of the experimental condition.

However, some differences between the stimuli in both conditions were inevitable. Due to the fact that some functions of the ISMCDM tool's system rely on the presence of image-schematic metaphors, not all ways of functioning were identically translated to the system shown in the control condition's stimulus which does not employ image-schematic metaphors[1]. The elements shown in the control condition's stimulus are arranged as rounded rectangles in an hierarchical manner and resemble those shown in the experiment condition's stimulus only in color. Therefore, *Issues*, *Propositions*, *Arguments, Counterarguments*, *Doubting Arguments* and *Conclusions* were marked with the abbreviations „*IU*", „*PP*", „*AG*", „*CA*", „*DA*" and „*CC*", respectively. *Doubting Arguments* could not take a form resembling that of *Issues,* so new *Propositions* originated directly from the element representing the *Doubting Argument*. Resolutions of *Doubting Arguments*, as well as the accepting of

[1] I.e. image-schematic metaphors that are not based on the image-schema CENTER-PERIPHERY, which is essential to the general nature of taxonomies.

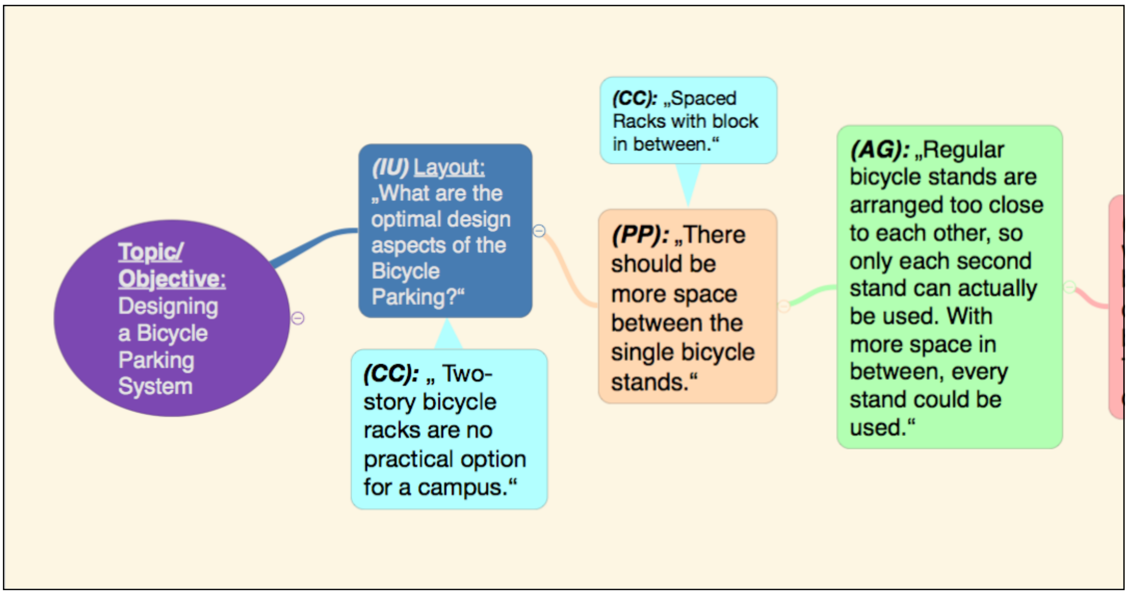

Figure 9. A possible arrangement of elements as represented by the fictional CDM tool that is presented in the control stimulus (part 1).

Propositions were indicated as *Conclusions*. *Conclusions* were displayed as regular blocks as were used for representing all other elements, originating from the element they referred to. Rating for certain *Arguments* and *Counterarguments* were not displayed, therefore, the resolution of some was not visible in the mind map either. The stimulus for the control condition therefore contained less slides and turned out to be of shorter duration. Due to a mistake during the course of compiling the materials for the experiment, the duration of each slide shown ended up to be five seconds instead of intended four seconds, resulting in a total duration of the video of 240 seconds. Figure 9 and Figure 10 show a selection of elements appearing in the present CDM case mapped to showcase this system's way of arranging them.

Both videos were uploaded to the video sharing platform Youtube (https://www.youtube.com/). This allowed a practical way of embedding the video for the experiment condition (Jan Rejek, 2017a) and the video for the control condition (Jan Rejek, 2017b) into the Qualtrics online survey. Comments, as well as ratings of the videos were disabled in order to counter possible bias. Also, the videos were unlisted, so they were not accessible via means other than the embedded web link.

A questionnaire of eleven items was compiled in order to test and compared the participants' knowledge retrieval from the stimuli. The items were semi-open questions, in this case affirmative sentences in which single parts of the sentence were left out. Participants were required to fill in the blank gap of the sentence in order to make it a true statement about

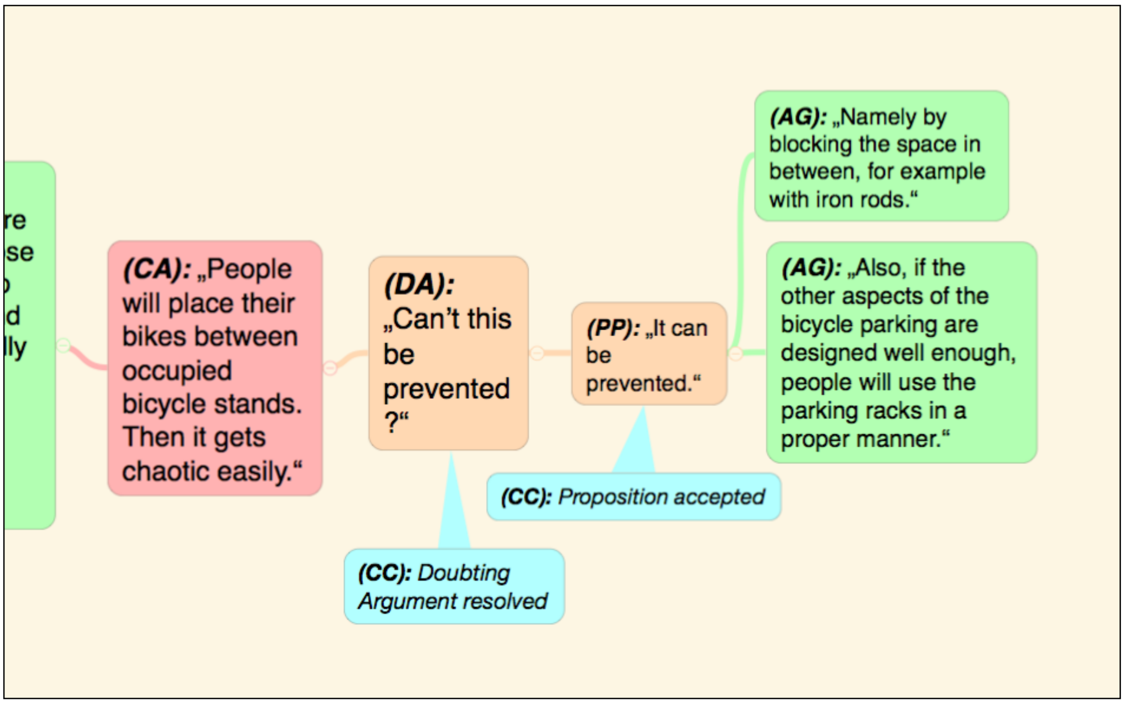

Figure 10. A possible arrangement of elements as represented by the fictional CDM tool that is presented in the control stimulus (part 2).

the CDM process previously seen in video. To give an example, one item stated ‚The Issue [blank] was settled first.' (In the survey, the blank was simply indicated by underscores). The correct answer would have been ‚Layout'. The configuration of this questionnaire was based on the researcher's subjective estimation of an overall understanding of structural, progressive and content-related aspects of the CDM case.

For assessing and comparing the participants' subjective user experience of the CDM system presented, a standardized questionnaire was derived from Schrepp (2015). It consists of 26 items in the form of a seven-stage semantic differential. Users were instructed to mark all items according to their subjective, honest impression. It was randomized per item with of the positive and the negative opposites was shown left and which right. Each of the item belongs to one of six scales, which are attractiveness (a pure valence dimension), perspicuity, efficiency and dependability (pragmatic, goal-directed dimensions), stimulation and novelty (hedonic, not goal-directed dimensions). It has to be said again that this questionnaire is part of a pilot test. So the relatedness of its scales, especially of the pragmatic, goal-directed dimension, to the construct of intuitiveness as main determinant for user experience in the sense of practicality and fidelity was assumed, but was not subject to further scientific investigation.

4.4 Procedure

Research subjects provided data in a purely digital way through the Qualtrics survey which they arrived at by following the website link. The first page visible contained the Informed Consent statement, including information about what to expect in the survey, as well as the researchers email address. Participants gave explicit informed consent by continuing the survey. With continuation, they were randomly assigned to either experimental or control group. It was not possible throughout the whole survey to go back to previous survey pages. On the following page of the survey, participants read the respective background information and instruction text, under which also the stimulus video was seen. Participants therefore had the possibility to inspect the instruction and background information while the video seen, as well as to rewind the video, which they weren't told. They were explicitly reminded that they were able to pause the video in case the a slide was shown too shortly for them to be able to read the associated text. Also, activating full screen mode while watching the video was recommended. The next page contained the knowledge retrieval questionnaire of 11 items, the page after that the 26-item user experience questionnaire. For the knowledge questionnaire, responding to each item was not strictly necessitated, but responses were requested with continuation to the next survey page, in case the participant did not fill in one or more text fields, in case the participant left out the item due to forgetting it rather than not knowing the right answer to the item. A response to the items of the user experience questionnaire was forced; all 26 items had to be marked. The last survey page was the debriefing of the participants. More background information about the study was given. In case of interest in the findings of this research, participants were free to leave an email address. A summary of these findings and more information was promised to be sent in the near future. The anonymization of data collected was reassured. Furthermore, participants were encouraged to leave a comment about the stimulus, the questionnaires, or anything else that came to mind during participation which they wanted to tell. Lastly the participants were thanked again, and researchers email address and name was stated for possible questions or complaints.

4.5 Analysis

The knowledge retrieval from the two different stimuli representing the same CDM process is operationalized as a score on the knowledge retrieval questionnaire (KR). Of its 11 items, nine were sentences with one blank each; one item contained two blanks, one item four blanks. Each blank was weighted evenly, except those of the four-blank item, which were weighted half. The motivation behind this was the fact that this particular item required an enumeration of words from the participant which were related to the content of the CDM process shown in both stimuli. Reproducing this is total of four words however was not estimated to be equally demanding nor to be equally representative of actual knowledge retrieval as four of the other items. Instead of one point, half a point was counted for each blank. Thus, the score could possible assume a number from 0 to 13. No formal rules or coding scheme were set concerning word count or choice of words within the within the participants' responses to assess their correctness. Rather, judging correctness succeeded under subjective intuition and empathy as well.

The participants' score on the 26-item user experience questionnaire (UE) operationalized their user subjective user experience of their respective stimulus. Due to the items being 7-staged semantic differentials, the score could possibly average out to a number between .00 and 7.00. Values for randomly reversed items were recoded in accordance with a higher score representing high user experience.

As said above, 45 of a total of 115 responses to the online survey itself counted by Qualtrics were unfinished and mostly did not provide actual responses to any of the forms of assessment employed. This means participation in the survey was stopped by the respective group of participants right after giving informed consent and being faced with the page that included the instruction to the experiment plus the stimulus. Of the remaining 70 responses, 21 were excluded because they were regarded unreliable, mostly judged due to obviously contradictory markings of the scales of the user questionnaire, markings of this questionnaire that followed a particular visual pattern, or evidently unserious responding to the knowledge questionnaire, e.g. answering the text fields with numbers. Furthermore, participants' responses were excluded when all items of the knowledge retrieval left out and only the user experience questionnaire was answered.

Tests of Normality showed that the scores on knowledge retrieval (KR) were normally distributed among all responses kept for analysis (n = 49). Therefore, for statistically comparing the average KR scores of the experimental group and the control group, a T-Test for independent samples was applied. The significance level of α = .05 was chosen. It is hypothesized that participants of the experimental group, presented with an image-schematically metaphoric stimulus (for the sake of brevity here referred to as ISM group), on average score statistically significantly higher than participants of the control group (here referred to as MM group, since the stimulus for the control condition was a mind-map-like representation).

$$H1_a : KR_{ISM} > KR_{MM}$$

Also the scores on user experience (UE) were normally distributed. Therefore, also in this case, a T-Test for independent samples (n = 49; α = .05) served as means for statistical comparison of the average UE of the experimental group and that of the control group. Similarly, a significantly higher average UE among participants of the experimental condition is hypothesized.

$$H2_a : UE_{ISM} > UE_{MM}$$

The purely qualitative responses of some participants, i.e. the comments which were optionally given at the end of the survey are no subject to scientifically verified methods of analysis. Rather, they are restated in below sections in a summarizing fashion, according to which overarching motives appeared the most present to the subjective judgement of the researcher.

5. RESULTS

Table 1 provides an overview of overall descriptive results which in addition includes the respective values of the upper and the lower quartile. A notable fact is that the maximum score of 13 points was reached, as was done by one participant of the experimental group. The minimum score attained was .50, as observable in both experimental and control condition, which accounts to one correctly answered blank of the four-blank item of the knowledge retrieval questionnaire. The average KR of the ISM group was 7.15 (*SD* = 3.53) significantly higher than that of the MM group, namely 4.52 (*SD* = 2.40). The first alternative hypothesis $H1_a$ is therefore accepted ($p = .004$; $\alpha = .05$).

The minimum UE of the experimental group, namely 3.35, and that of the control group, 3.38 were fairly alike, whereas the maximum score observed within the experimental group was 6.65 and that within the control group was 5.65. No statistically significant difference ($p = .20$; $\alpha = .05$). was found between the Mean UE of the experimental group ($M = 5.06$; $SE = .78$) and that of the control group ($M = 4.78$; $SE = .67$). Thus, the second alternative hypothesis $H2_a$ is rejected.

Table 1

Descriptive Statistics of scores on knowledge retrieval and user experience per condition

		n	Minimum	Q1	Q3	Maximum	Mean	Std. Deviation
KR	ISM	26	.50	2.50	7.00	8.50	4.52	2.40
	MM	23	.50	4.59	9.00	13.00	7.15	3.53
UE	ISM	26	3.38	4.58	6.46	6.65	5.06	.78
	MM	23	3.35	4.19	5.65	5.65	4.78	.67

A total of 15 participants left a comment at the end of the survey (listed in Appendix I), of which seven provided results that were excluded. The topic most commonly commented on was the knowledge retrieval questionnaire and the way it was constructed. Two participants stated that single parts of it were not ambiguous fully clear. Furthermore, it was stated twice that cues of what kind of answer was required to fill the blank with would have been of help against possible ambiguity. For example, the last item stated „ The chaos of bikes put between bikes shall be reduced by [blank].“ Just according to the structure of the sentence, a possible answer could have been e.g. a percentage, instead of an action. Another aspect that was questioned twice by participants was wether it made sense to test whether specific amounts of elements were memorized. The second most apparent motif to be found in the comments is the aspect of difficulty of memorization of content shown in the specific form of the stimulus, namely a the video. The slideshow seen in the stimulus was criticized to skip to the next side too quickly, which was stated by participants of both the experimental an the control condition. An aspect criticized by participants of the MM group was that elements indicating *Propositions* and elements symbolizing *Doubting Arguments* were of the same color and that this should be improved. Lastly, two participants, both of the ISM group, expressed their enthusiasm and enjoyment of the stimulus and the system it presented.

6. DISCUSSION

6.1 Interpretation of Results and Limitations of the Experiment

As was hypothesized, subjects presented with an image-schematically metaphoric representation of a CDM process did exhibit significantly higher knowledge retrieval of the CDM case than subjects presented with a mind-map-like representation. Looking at this result in regard of the research question, it is safe to say that the application of the image-schematically metaphoric design created in the course of this thesis resulted in higher knowledge retrieval retrieval. However, whether or not the cause for this result were the very analogy and representativeness as properties effectuated by this particular composition of image-schematically metaphoric design aspects can not possibly be said.

Contrary to the second hypothesis, no significant difference in subjective user experience was found between the experimental group and the control group. As it is the case with knowledge retrieval, a conclusion from this result can only be made regarding the user experience of stimuli applied in this particular experimental design, not regarding the actual CDM systems presented.

Once more, it has to be restated that due to the given frame of time and workload of a bachelor thesis, the pilot test of the ISMCDM tool was merely a preliminary attempt of studying its qualities, and therefore comprises major methodological shortcomings and other sources of bias. The main determinant for these is the fact that the ISMCDM Tool was not actually produced and therefore not its active use was assessed, but its passive use mimicked and assessed. This affected multiple stages of the study.

Firstly, the nature of the stimuli, that is passive use of the system shown in the form of a video, necessitated a rather extended instruction form. Based on this instruction, the overall informal logic of the respective CDM system had to be understood by the participants in order to provide data, which complicated the success of instruction itself. This is highly contrasting to the effects tried to attain by the design of the ISMCDM in the first place, among which a low cognitive workload as part of experienced intuitiveness. Moreover, it is reasonable to assume that this, next to the fact that the data were gathered online and under complete anonymity, is among the main reasons for the relatively high number of unfinished survey responses to the survey, and the additional responses which had to be excluded. Another source of bias considered in regard of the willingness to read a rather long instruction, watch the stimulus, and lastly to fill out two questionnaires seriously, is the state of the day among the participants.

Secondly, active use of the ISMCDM Tool is estimated to be crucial for the users' objective retrieval of information about the CDM process from the visual representation, as well as subjective user experience, including intuitiveness. Active use includes the users actual participation in forming the CDM process, and thus the visual mapping of the image-schematically metaphoric representation of it. The CDM process is witnessed gradually and over the course of periods longer than the duration stimulus. The reliance on short-term memory was an aspect of the stimulus frequently criticized by participants. Furthermore, the collaborative dialog is coined by meaning, self-interest and motivation; which is another aspect lacking in passive use, as stated by some participants.

A further flaw of the stimulus for the experimental condition, when it comes to showcasing the full extent of practicality of the ISMCDM Tool, was that the complete range of its features was not brought into display. On the one hand, design aspects that expressed image-schematic metaphors, such as the scaling of particular elements according to relevance or recency, and shadings of *Arguments* and *Counterarguments* to indicate their rating, were not included in the stimulus. Moreover, the color gradient of *Propositions* did not shift according to their CONTENT. On the other hand the concrete ways of how rating for *Arguments* or *Counterarguments*, requests to resolve certain elements or to formulate conclusions were carried out, were not made visible in the stimulus. Although the latter may not be directly imply a lack of expression image-schematic metaphors, they certainly form another aspect in which the stimulus differs from the actual ISMCDM tool's design as a whole.

Inevitably, the differences between both stimuli mentioned above made fully accurate direct comparison impossible. One evitable aspect though is the mistake of different durations for which the slides of the two different stimuli were made visible. On the one hand, subjects assigned to the control condition had one whole second more to read the textual information given per slide that subjects of the experimental condition. On average, the knowledge retrieval was significantly higher among the experimental group than among the control group. Assuming that a longer duration of the stimulus for the did not significantly result in hindered memorization of the CDM case, it this error can be considered negligible. On the other hand, it is a source of error that has to be taken into account when it comes to assessing user experience. A difference in duration may have biased the responses to specific items, of which most prominently the item „fast — slow", and therefore the entire UE score.

Lastly, the results delivered by the two questionnaires were biased and therefore not fully trustworthy. The knowledge retrieval questionnaire was compiled provisionally and did not go through any process of validation or standardization. It can't be said whether the way the questionnaire was compiled facilitated higher scores among either the experimental or the control group or not. The user experience questionnaire employed was a standardized questionnaire for assessing user experience. Although the relation between its dimensions and intuitiveness was assumed, it is not proven. Apart from that, it was constructed for the assessment of actually produced systems, as some items explicitly implied active use. Due to this fact, in combination with the qualitatively different nature of both stimuli, direct between-groups comparison of them by these quantitative methods can not possibly be fully valid.

6.2 Evaluation of the ISMCDM

A number of improvements of the ISMCDM System have been conceptualized along with reflection during the conduction of the research. One is the animation of the new elements placed or modified in the representation of the CDM process. For example, instead of instantly appearing, elements would emerge from their superordinate element, i.e. their predecessor, and the closing of a CONTAINER such as a *Proposition* would be displayed in motion. This would be coherent with image-schemas referred to by the ISMCSM, and therefore has the chance to reinforce the visual apparentness of image-schematic metaphors. Moreover, animating movement of the elements would help with update for users who have been missing the most recent progress of the collaborative dialog.

Some of the rules about the arrangement of elements are subject to improvement. Allowing *Issues* to be placed within *Issues*, can be of practical use in some contexts of collaboration, is consistent with the previous application of image-schematic metaphors (Figure 11). In some situations, it can be necessary that there is more than one *Counterarguments* opposing an *Argument*, or vice versa. This shall be possible by scaling the

Figure 11. Issues within *Issues* are possible.

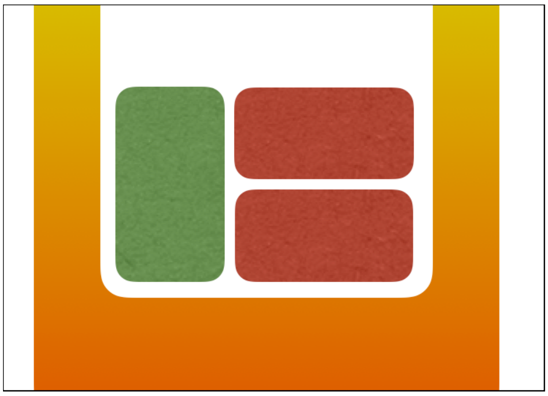

Figure 12. Two *Counterarguments* against one *Argument*.

heights of elements that stand in opposition (Figure 12). The order in which *Arguments* as well as *Counterarguments* were arranged above each other was until now determined by the order in which they were placed. Users shall have the possibility to chose gravity of *Arguments* and *Counterarguments*, i.e. their ratings, as an alternative to the criterium of recency as determinant for vertical alignment. If the user choses this view, elements with higher ratings are displayed closer to the floor of the interface. This corresponds again with the image schema CENTER as well as HEAVY. Similarly, the user shall have the option to chose either recency or gravity of elements as determinant for their scaling in the interface.

6.3 Implications for Future Research

In order investigate the role of image-schematic metaphors within the blended space, the design aspects of the ISMCSM tool have to be tested anew. Recommendations for future research incorporating multiple methods can be derived from above conclusions. The prerequisite for the following recommendations is the actual production of the CDM tool, including the implementation all aspects of design, and all functions required for realizing practical use, as elaborated above.

An actually existing ISMCDM Tool would cancel out most shortcomings of this pilot test mentioned above. Its assessment would not necessitate instruction via an extended form, as applied in this study. Instead, instruction can succeed step-by-step within use of the software, as well as by means of example-based methods. However user-friendly, intuitive, practical, etc. the ISMCDM Tool may be when its way of functioning is once fully understood by its users, also an effect of image-schematic metaphors in interface design on inclusiveness of the interface has been claimed by multiple lines of research (Hurtienne, 2007). The ISMCDM Tool's inclusiveness can be investigated by assessing user experience and behavior among users presented with different extents and designs of instruction.

Among other forms of assessment, the user experience questionnaire employed in this study could perfectly applied to a fully functioning ISMCDM. Also, the comparison of user experience of the ISMCDM Tool to that of another CDM tool would not strictly be necessary, since the questionnaire comes with validated benchmark values (Schrepp, 2015). Questionnaires for assessing knowledge retrieval have to undergo constant revision. Instead, more suitable methods are of qualitative kind, e.g. interviews. When it comes to actual intuitiveness experienced during use, in the sense of the definition by Hurtienne (2017), as cited above, as well as representativeness, a multitude of methodologies can serve to investigate the question to which is extent this is the case.

A key direction of research is the exploration of the application of single image-schematic metaphors to the ISMCDM Tool. Comparing versions of the tool different in regards of compositional aspects of its visual design, allows the investigation of the individual role of different image-schemas for experienced intuitiveness. This can be attained by modifying or removing single image-schematically metaphoric design aspects, and assessing and comparing the tool's altered version's qualities to those of the original version.

A further recommendation the is research after the quality of the relation between compositional aspects of the a blended space interface and a multitude of other factors and measurements that are individual to the user. Besides user experience and knowledge retrieval, these include different demographic data such as cultural context and educational background, biographic information and psychometric measurements, and, most importantly in regard of intuitiveness and representativeness of the ISMCDM Tool's representation for the users actual way of perceiving the CDM process, elicitations of mental models from psycholinguistic samplings. Mentionable methods are interviews as well as card sorting studies; further possibilities of research reach out into the field of biological measures such as eye tracking.

One concrete aspect of investigation is the construct of creativity. Johnson (1987, p. 170) points out a direct link of image schemas and image-schematic metaphors towards creativity, stating that ‚We are imaginatively creative every time we recognize a schema in a new situation we have never experienced before and every time we make metaphorical connections among various per conceptual and conceptual structures‘. Hennessey & Amabile (2017) name a variety of level on which creativity forces operate, ranging from the neurologic level over developmental and biologic levels to social and cultural contexts. This corresponds with the multimodal nature of image-schemas mentioned by stated by Hurtienne (2017). Another topic linked to the comprehension of metaphors, and therefore to the responsiveness to the expression of image-schemas, is psychopathology. Impairments observable on a. o. the linguistic, cognitive and neural levels, as mentioned by Hennessey & Amabile (2017), are known to occur in cases for example of schizophrenia (Pawełczyk, Łojek, & Pawełczyk, 2017) as well as aphasia (Cieślicka, Rataj, & Jaworska-Pasterska, 2011). Although not necessarily a pathologic condition of perception, also synesthesia might effect the interpretation of multi-modal references to image schemas.

All in all, concrete overarching conclusions about the optimal extent of application of image-schematic metaphors in interface design can not yet be made. At this point it is appropriate to refer to how the term ‚ontology’ is defined in its original context, which is philosophy, namely as ‚a branch of being metaphysics concerned with the nature and relations of being‘ (https://www.merriam-webster.com/dictionary/ontology). It is safe to say that when it comes to the design of an ontology technologies applied in collaborative contexts, the ontology on an experiential level of the consensus of the communicating parties has to be its major guideline.

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APPENDICES

Appendix A - Informed Consent Statement

Informed Consent Form

Dear participant,

thank you for volunteering in this online survey. It is part of a pilot study that tests a Collaborative Decision Making tool (something comparable to an online discussion board) and investigates its design aspects.

In the following experiment you are going see a series of visual representations of communication. There will be an instruction that goes more into detail of the task itself. After this series of representations you will have to fill out two questionnaires that assess your understanding and your experience of these representations. It takes about 30 minutes to complete this experiment. By continuing, you ensure that you acknowledge the following:

Participation in this experiment is purely voluntary.
It is allowed to stop participating at any time, without justification. However, this excludes you from further participation in this survey.
The legal age for participation is 18 years.
There is no payment or other form of remuneration for participating in this experiment, other than Sona Credits (if you are a student at the University of Twente).
All data gathered in this research will be anonymized by the researcher immediately (if applicable at all).
The conduction of this experiment has been approved by the Ethical Commission.

In the case of any questions or complaints, the present researcher can be contacted via
j.m.rejek@student.utwente.nl .

Appendix B - Instruction and Background Information for Experiment Group

Instruction & Background Information

Collaborative Decision Making (CDM) describes the process of two or more individuals collectively making a decision. That can be any form of communication where alternatives and options are presented and choices picked; for example collaboration on a design task, a regular discussion about a particular topic where opinions are exchanged, or devising a plan about future events, etc.

Digital tools such as softwares and web applications are being devised that *structure and visualize the content* of the CDM process. This can help collaborators to make decisions collectively, despite spatial distance and temporal delay. Also, using such a tool can offer the chance to make the CDM process more fruitful, since it is structured from the beginning.

The CDM tool shown in this study is thought a browser-based software that can be used by everybody who is invited to the particular topic. Users are able to contribute to the CDM process by choosing between five different elements, namely **Issues**, **Propositions**, **Arguments**, **Counterarguments** and **Doubting Arguments**, and formulating its actual meaning in the form of text. Only these elements are then displayed as different shapes (see below) on the interface, i.e. the screen. The element's meaning pops up in a text window when the user hovers over its respective shape with the mouse cursor.

In the following part of this survey, a CDM process will be shown to you as it *would be* visualized by this CDM tool. Its a brainstorming session held by a handful of individuals about ***how a bicycle parking system on the campus of the University of Twente best should be designed***. It will be presented to you in the form of a slide show. With each new slide, a new element comes into display. The meaning of the element appears at the same time and in the same slide (Unlike during active use of the software, the function of the mouse cursor hovering over the shapes does not exist).

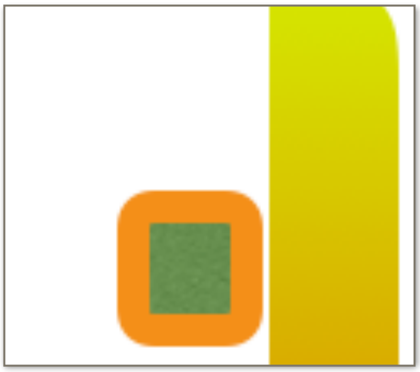
Your task is t to watch a video of this slide show and understand the development of the CDM process.The slide show is followed by a questionnaire that assesses your understanding of the CDM process, as well as a questionnaire that assesses your subjective experienced intuitiveness of the CDM tool.

An **Issue** within the interface of the CDM tool takes a blue, platform-like shape. The purple bottom represents the overarching topic of the CDM process.

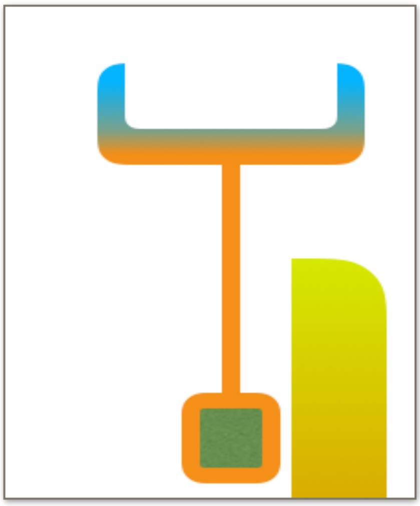
A **Proposition** is a statement of an opinion, in the CDM process mostly regarding an action to be taken. It is displayed as a shape similar to a container, or vase. Its color ranges from yellow to dark orange.

In the CDM tool, an **Argument** is a statement that is formulated *in favor of* the proposition. Arguments are indicated by green rectangles inside the shape that symbolizes a proposition.

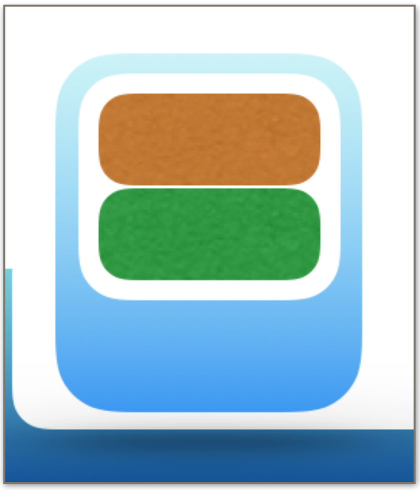
A **Counterargument** takes the shape of a red rectangle and is also visible inside the proposition-shape. Counterarguments are directed *against specific* (Pro-)Arguments if they are placed directly next to the Argument. Otherwise, they *counter only the proposition* in general.



Doubting Arguments are displayed as orange frames, or hollow squares, on top of an Argument or Counterargument.



Often the reason for doubting an argument can turn into a whole discussion on its own. Users therefore have the possibility to *expand* the **Doubting Argument** so that it becomes an **Issue**. This is signified by a shape similar to the original platform-like Issue-shape that is connected by an orange line to the Doubting-Argument-shape. It offers ground for Propositions and ongoing parts of the CDM process. An **Issue** that is built upon a **Doubting Argument** can be *resolved*. The shape then disappears.



Users have the possibility to vote for, as well as resolve Arguments and Counterarguments.

A ***conclusion*** regarding the original proposition can then be formulated. This is signified by a Proposition-shape, that is now closed instead of open at the top, and has changed in color.

Similarly, if users have come to a conclusion for every proposition, the Issue-shape can *close around* the propositions, and a *conclusion*, such as a summary of the outcomes of the discussion, can be formulated for the issue as well.

Appendix C - Instruction and Background Information for Control Group

Instruction & Background Information

Collaborative Decision Making (CDM) describes the process of two or more individuals collectively making a decision. That can be any form of communication where alternatives and options are presented and choices picked, such as collaboration on a design task, a regular discussion about a particular topic where opinions are exchanged, or devising a plan about future events, etc.

Digital tools such as softwares and web applications are being devised that *structure and visualize the content* of the CDM process. This can help collaborators to make decisions collectively, despite spatial distance and temporal delay. Also, using such a tool can offer the chance to make the CDM process more fruitful, since it is structured from the beginning.

In the following part of this survey, a CDM process will be shown to you as it *would be* visualized by a fictional CDM system. This system is thought of as a browser-based software that can be used by everybody who is invited to the particular topic. Users are able to contribute to the CDM process by choosing between five different elements, namely **Issues**, **Propositions**, **Arguments**, **Counterarguments** and **Doubting Arguments**, and formulating its actual meaning in the form of text. These Elements are then arranged and displayed in a form of a *Mind Map*. There is a number of rules (see below) users of this tool have to follow when formulating placing new elements to the mind map.

The CDM process you are about to see is a brainstorming session held by a handful of individuals about ***how a bicycle parking system on the campus of the University of Twente best should be designed***. It will be presented to you in the form of a slide show. With each new slide, i.e. with each new page within this survey, a new element of the mind map comes into display.

Your task is to watch a video of this slide show and understand the development of the CDM process.The slide show is followed by a questionnaire that assesses your understanding of the CDM process, as well as a questionnaire that assesses your subjective experienced intuitiveness of the CDM tool.

<u>Rules of the CDM tool:</u>

An **Issue (IU)** is formulated regarding the main topic of the CDM process,

A **Proposition (PP)** is a statement of an opinion, in the CDM process mostly regarding an action to be taken. A Proposition always has to be followed by an **Argument (AG).**

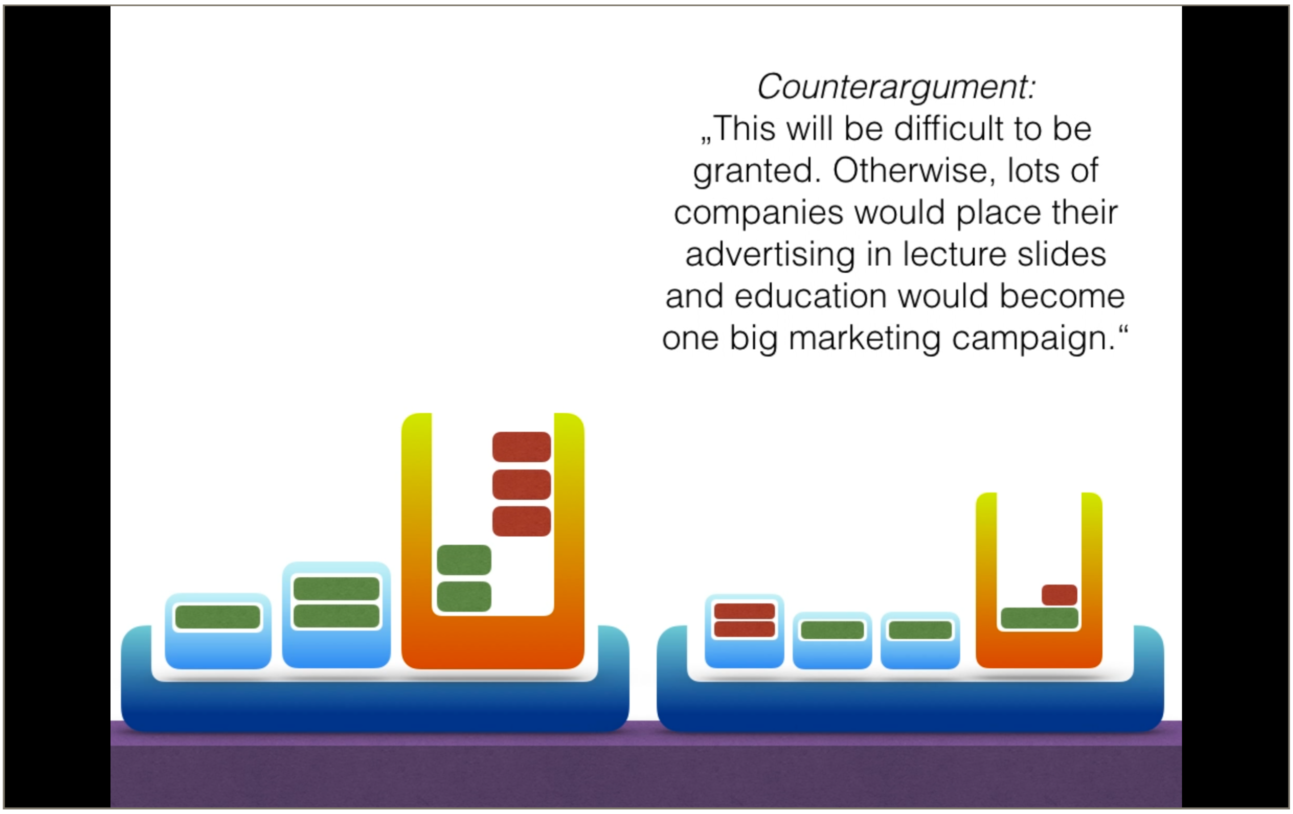
An **Argument (AG)**, therefore, is always a statement that is formulated *in favor of* the the proposition.

A **Counterargument (CA)** can be formulated against a Proposition, as well as against particular Argument.

Doubting Argument (DA) is a statement that questions or doubts a certain Argument or Counterargument.

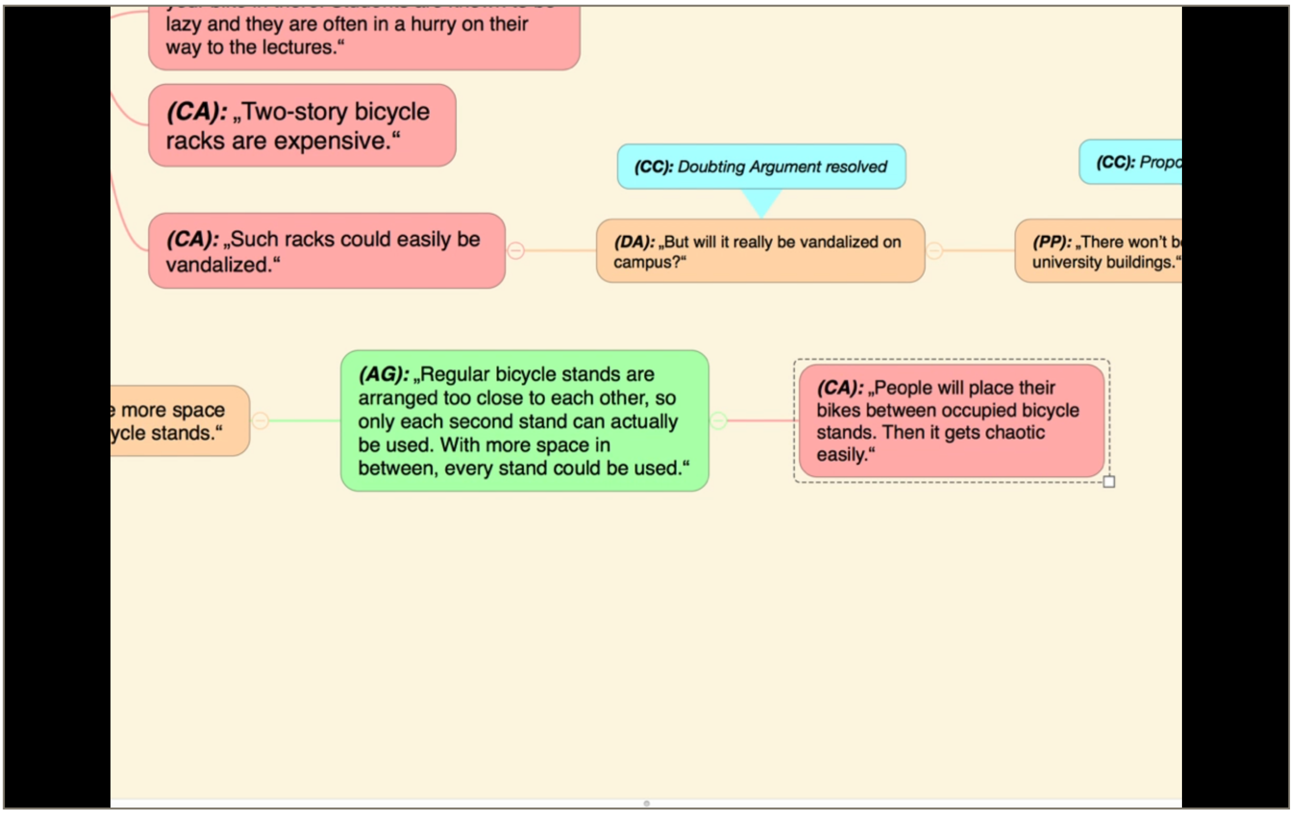
Users have the possibility to vote for and resolve Arguments, Counterarguments and Doubting Arguments. This is signified by elements with the label **Conclusion (CC)**. Moreover, Conclusions can be drawn regarding Propositions and Issues.

Appendix D - Stimulus for the Experimental Condition



Video 1 Image-Schematically Metaphoric Stimulus

Appendix E - Stimulus for the Control Condition



Video 2 Mind-Map-Like Stimulus

Appendix F - Knowledge Retrieval Questionnaire

The following semi-open questions are supposed to test your knowledge retrieval from the stimulus you just saw. Complete the shown sentences in the text field below it. In case of more than one required answer, separate your answers with a semicolon (;).

1.) There were ______ Issues in total (which were not based on Doubting Arguments).

2.) There were ______ Propositions in total (regarding Issues not based on Doubting Arguments).

3.) There were ______ Doubting Arguments in total.

4.) A total of ______ doubting argument(s) was/were formulated for arguments, ______ for counterarguments.

5.) The Issue ______ was placed first.

6.) The issue ______ had the highest number of different propositions.

7.) Methods for promoting the app include ______, ______, ______, ______.

8.) The Issue ______ was settled first.

9.) The Proposition longest without in a conclusion suggested that ______.

10.) The proposition suggesting that ______ was the proposition with the most arguments and counterarguments in total.

11.) The chaos of bikes put between bikes shall be reduced by ______.

Appendix G - User Experience Questionnaire

The following questionnaire assesses user experience. Mark the scales according to your personal, subjective experience of the CDM system presented to you the video (not other parts of this survey or the survey in general).

annoying	○	○	○	○	○	○	○	enjoyable
good	○	○	○	○	○	○	○	bad
unlikable	○	○	○	○	○	○	○	pleasing
pleasant	○	○	○	○	○	○	○	unpleasant
unattractive	○	○	○	○	○	○	○	attractive
unfriendly	○	○	○	○	○	○	○	friendly
fast	○	○	○	○	○	○	○	slow
inefficient	○	○	○	○	○	○	○	efficient
practical	○	○	○	○	○	○	○	impractical
organized	○	○	○	○	○	○	○	cluttered
not understandable	○	○	○	○	○	○	○	understandable
difficult to learn	○	○	○	○	○	○	○	easy to learn
easy	○	○	○	○	○	○	○	complicated
confusing	○	○	○	○	○	○	○	clear
predictable	○	○	○	○	○	○	○	unpredictable
obstructive	○	○	○	○	○	○	○	supportive
not secure	○	○	○	○	○	○	○	secure
meets expectations	○	○	○	○	○	○	○	does not meet expectations
inferior	○	○	○	○	○	○	○	valuable
exiting	○	○	○	○	○	○	○	boring
not interesting	○	○	○	○	○	○	○	interesting
demotivating	○	○	○	○	○	○	○	motivating
creative	○	○	○	○	○	○	○	dull
conventional	○	○	○	○	○	○	○	inventive
usual	○	○	○	○	○	○	○	leading edge
innovative	○	○	○	○	○	○	○	conservative

Appendix H - Debriefing Form

Debriefing

The online survey you just completed is part of a Bachelor thesis. It investigates the extent to which so called image schemas should be incorporated in the design of certain data visualization tools, in this case a Collaborative Decision Making tool, in order to enhance usability. Image schemas are „neural pattern[s] formed from repeated patterns of action and perception in the environment“ (Hurtienne, J. (2017). How Cognitive Linguistics Inspires HCI: Image Schemas and Image-Schematic Metaphors. *International Journal of Human-Computer Interaction, 33*, 1-20. doi: 10.1080/10447318.2016.1232227). For example, if you were to ask people „If you have the two pairs of words ‚Big - Small' and ‚Strong - Weak', which word of the one pair belongs to which word of the other pair?“, virtually all of them would answer : „Big is Strong; Small is Weak.“, because years of experience have taught the profound association that big things tend to be stronger than small things. Examples of similarly known image schemas are „Important is Heavy; Irrelevant is Light.“ and „Time goes from Left to Right“.
If you are interested in a summary of the findings of this research, you can sign up for it by leaving an email address of yours below. Once I have finished the research project, I will send the summary to you. Once again, I ensure that all data gathered are anonymized immediately.
[Qualtrics text field for optional email address]

Also, please feel free to leave a comment in the text box below regarding any issue related to this particular survey, whether that be your personal experience of the survey, or aspects of the design of the visual representations or of the questionnaire, etc.
[Qualtrics text field for optional comment]

In case of any other questions, complaints, feel free to contact me via j.m.rejek@student.utwente.nl .

Kind regards and thanks again,
Jan Rejek

Appendix I - All Comments Given

1.) „I have to admit I was confused and it was rather hard to follow the video as it was very fast“
(*ISM group, excluded*)

2.) „One of the very first questions (I believe it was either 7 or 8) was weirdly formulated and in my opinion unintelligible. It would also have helped if there was an instruction that clearly states that the answer of the first couple of questions were numbers because as someone who doesn't know what he clearly should do, I was a bit wary if I was answering correctly.“
(*ISM group*)

3.) „It might be helpful to give the opportunity to watch the video again when answering the specific question with how many arguments and so on, I mean I watched the video but I made a short break in-between before i clicked further and I did not make notes so forget quite a few things“
(*ISM group, excluded*)

4.) „First of all I like the idea of the video, but it would have probably been better to show each different slide a little bit longer, so you had enough time to read it without pausing it (which you had to do at some point because the texts were quite long sometimes), which would make the video more intuitive and it would help to memorize some of the other parts, like how many issues or propositions were made (since you would have more time to look at the screen in general instead of trying to read the texts as fast as possible. Also I think it would be helpsome if you added some kind of text to the questionnaire at the end that suggests what each point meant, like efficiency in general or compared to other methods of arguments or collaboratively deciding something. But aside these two minor comments I think it was a very pleasing experience regarding the concept, the visualization and the questionnaire at the end. Cheers and good luck“
(*ISM group*)

5.) „I think it could be usefull but it is difficult to keep your attention on a silent movie on a topic that I'm not very interested in. This made it so that I could not answer a lot of the questions about the movie.“
(*MM group*)

6.) „it would be nice to watch the video again“
(*MM group, excluded*)

7.) „I don‘t think that the number of arguments ist so important that a tool should focus on making that more memorable.“
(*MM group, excluded*)

8.) „Even though it was easy to follow the actual meaning of the shown argumentation-graphic after some time, it was still pretty difficult to answer the questions since it was really hard to remember all the whole (argumentative) content of the video. In order to prevent empty answer boxes, the task could have been enunciated clearer and with the focus on the fact that the participant is not only supposed to understand the general frame of this argumentation, but also that they also have to be able to reproduce the actual content.“
(*MM group*)

9.) „In my opinion it’s not important for a study to know how many (counter-)arguments on certain topics/propositions and other dismissal information there are but the arguments themselve and the outcome is what counts and that is what should be concentrated on.“
(*ISM Group, excluded*)

10.) „Perhaps it could be better to use different Colors for propositions an doubting arguments.“
(*MM group, excluded*)

11.) „I really enjoyed the different steps, but mostly the tools that were used to come to a conclusion oder decision. They were easy to understand and one could simply follow the process of decision making.“
(*ISM group*)

12.) „Design suggestion: avoiding the same colour-sceme for proposals (PP) and counter arguments (DA) could improve the clarity of functions of the different discussion elements.“
(*MM group*)

13.) „video was way too fast - missed to stop, so nothing memorized. too bad“
(*ISM group, excluded*)

14.) „Very very impressed! I really liked how you built the CDM tool and it was very clear structured and perfectly good to understand. I kind of slacked to remember everything but in that moment of the presentation it was easy to follow and easy to understand. Well done, hope it all works out!
(*ISM group*)“

15.) „What happens if a subissue or proposal can't be closed? Is the whole decision process stopped?“
(*ISM group*)