Effect of Map Sharing and Confidence Information in Situation-Map Making

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ABSTRACT

Motivation – A situation map that shows the overview of a disaster situation serves as a valuable tool for disaster response teams. It helps them orientate their location and make disaster response decisions. It is, however, a quite complicated task to rapidly generate a comprehensive situation map of a disaster area. In this paper, we report on an investigation of how two persons can collaborate to make a situation map.

Research approach – We performed a controlled laboratory experiment, in which 32 participants (grouped into 16 pairs) made a situation map of incidents. The experiment was set up as a two-way repeated-measures design with the type of collaboration and the availability of confidence level information as within-subject factors.

Findings/Design – The results suggest that the collaboration type can affect the quality of the situation map. Additionally, the results also suggest that the availability of confidence information influences the discussion process during collaboration. The participants perceived the availability of confidence level information as being positive.

Research limitations/Implications – The order of using the types of collaboration might have caused a learning effect by participants. Furthermore, the lack of a practice session might have had an influence on participants' object recognition during the first session of the experiment.

Originality/Value – The study takes the position that the affected population in a disaster can actively participate in the situation-map making process.

Take away message – Situation map-making might benefit from a simple collaborative action such as sharing a map including confidence information.

Keywords

Collaboration, sensemaking, situation mapping, disaster response, map sharing, situation awareness.

INTRODUCTION

After a disaster impact, such as earthquake or flooding, where infrastructure is devastated, the extent of the damage needs to be continuously analyzed in order to understand the conditions on the ground. This is necessary as a key component of naturalistic decision-making, where decisions and actions in the dynamic environment are based on the available information. The process of familiarizing, analyzing, understanding and keeping track of what is going on, is known as sensemaking, and the outcome of this action is situation awareness (Klein, Moon, & Hoffman, 2006).

A situation map is one form of situation awareness as the product of the sensemaking process. This map serves as a tool to see the overview of the disaster situation based on geo-spatial information at a particular time. It may contain information indicating whether an area is safe, a road network is passable, a place is destroyed, etc. It can also indicate the locations of evacuation shelters and emergency facilities. This information is needed so that emergency services and supplies can be mobilized.

Unfortunately, due to lack of resources to collect and assemble complete situation information, it is usually not trivial to construct this kind of map. Learning from the mass-casualty disasters in the past, overwhelmed local emergency services and limited emergency facilities are some of the biggest problems faced immediately after these disasters struck.

In order to overcome this problem, one of the possibilities is to find potential resources and then to support them to gather situation information collectively and continuously. Research conducted by disaster sociologists suggests that the population affected in a disaster can be considered as a potential resource instead of helpless victims, since they are still capable human beings during disaster situations (Drabek & McEntire, 2003; Dynes, 1994; Quarantelli, 1999). If we examine the numbers of natural disasters over the last thirty years, we see that the affected people who are neither killed nor injured in the disaster are the majority of the group, accounting for about 90% of the affected population (Guha-Sapir, Hargitt, & Hoyois, 2004). We can therefore argue that by supporting the affected population with simple technology, a collective effort may improve and expedite the process of constructing a high quality situation map compared to traditional collection methods.

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Despite the fact that the affected population can serve as potential collaborators during the mapping process, there is still little technological support developed for them. Recently, there were several attempts to use micro blogging services such as Twitter in reporting events in disaster situations (Vieweg, Hughes, Starbird, & Palen, 2010). In a similar manner, an open source map project called OpenStreetMap was used extensively during the Haiti earthquake in 2010 (n.d., 2010). Nonetheless, little research has focused on how to provide the affected population with support to help them, and specifically allow them to rapidly construct a collaborative situation map.

From our previous field observations and studies (Gunawan, Oomes, Neerincx, Brinkman, & Alers, 2009), we took the position that a situation map should be shared by all parties involved during a collaborative response effort. Additionally, voice communication should not be the only channel used for conveying geo-spatial information. Instead, it should be used in conjunction with the shared map. This method might serve as a verification mechanism to check the constructed situation map. In addition, information entered into the system should be accompanied by some degree of certainty that indicates the level of confidence of the individual reporting an event.

In this study, we investigated the effect of map sharing with or without voice communication and the availability of confidence level information on situation–map making. We performed a comparative evaluation in a controlled laboratory experiment. The results suggest that situation-map making by sharing a map is more effective than maps made without any collaboration. Furthermore, a shared map in addition with voice communication seems superior to collaboration with only a shared map. Although the availability of confidence level information was received positively by the participants, it had no effect on the quality of the situation map produced. Instead it had some influence on the discussion process during collaboration.

RELATED WORK

We begin our coverage of the literature with a viewpoint looking at affected population in a disaster as capable individuals instead of helpless victims. We then describe how these new potential resources can be used actively during disaster response. Recent disaster events provide us with showcases where new technologies such as microblogging and opensource-mapping are effectively used in assisting rescue efforts. Finally, we describe our analysis of the domain by conducting field observations and conducting preliminary experiments in collaborative map-making as the basis for this study.

Public as a resources

The current model of disaster management, derived from the military centralized command-and-control model, treats the affected population as helpless victims without ability to help themselves, let alone help other human beings. However, disaster sociologists have shown that the opposite is actually true regarding the affected population. Studies over 50 years of human response to disaster situation discredits disaster myths, such as panic and anti-social behaviour (Quarantelli, 1986), and instead shows the cohesive and unified emergent phenomena, such as a calm and helpful behaviour, of individuals or groups during situation of collective stress (Drabek & McEntire, 2003; Quarantelli, 1999; Wenger, Quarantelli, & Dynes, 1986). As a result, Drabek & McEntire (2003) and Dynes (1994) suggest the possibility for elaborating and expanding the command and control model with a participative effort, allowing for a decentralized and flexible structure that accommodates collaboration between professional actors and the public.

Collective effort

Landgren (2007), through extensive ethnographic fieldwork with a number of different fire and rescue services in Sweden, suggested that the collective effort of sensemaking is fundamental for successful response work. This collective effort should focus on information sharing in social interaction among the response actors involved and the transparency of their actions in the ongoing work. He suggested that, by making use of digital traces of team member actions, it is possible to provide collaborative visibility of the work, so that it improves the capacity for sensemaking in time-critical ambiguous events. These factors should be carefully taken into consideration when designing collaboration support system so that they are built into the way such a system is designed and used.

Collaboration technology in disaster response

There are already some efforts aiming at using new technology in disaster response. These kinds of efforts are continuously gaining more popularity and recognition. For example, a recent study by Vieweg, et al. (2010) investigated microblogging (Twitter) as a medium to harvest information during the Oklahoma Grassfire of 2009, and the Red River Floods of 2009 for the purpose of improving situation awareness. The study identified geo-spatial information and situational update as two important features generated during emergencies that accounted for improvement in situation awareness. However in microblogging, the users are limited to describing the geo-information either by mentioning geographical information such as city and road or location-referencing. Thereby they use a prominent landmark as the reference base, since they are not capable of pinpointing their exact location. Hence, an additional intermediate step is needed to convert this information into data that can be pinpointed on the situation map.

During the recent Haiti 2010 earthquake (n.d., 2010), there were substantial efforts using OpenStreetMap (Goodchild, 2007), where there was a massive rapid mapping progress in a very short period of time. Haiti did not have a digital map before the disaster. However, within 48 hours of the earthquake, a complete map of Port-Au-Prince and Carrefour were completed. This was achieved by the collaboration of hundreds of mappers around the world using post-quake aerial imagery. The resulting digital map was used extensively for the disaster response in Haiti, by emergency services and humanitarian organizations for damage report, search and rescue missions, and transportation purposes. In this example, the collective effort shows a successful collaboration during crisis events. The map could have been extended to a much more powerful use by making it accessible for the affected people in the disaster area itself.

Field observations and preliminary experiment

The field observations in our previous study (Gunawan, Oomes, Neerincx, et al., 2009), indentified three important issues during disaster response exercise at the Rotterdam-Rijnmond Safety Region in the Netherlands. First was the use of improper modality, in this case the sole use of verbal communication, to relay geo-spatial information across distributed team members. Since it is difficult to pinpoint an exact location using a verbal description, this often results in inaccurate exchange of location information. Secondly, because the situation map was not shared across the distributed team members, errors committed as a result of the above-mentioned problem were not quickly detected. The third issue was that the rescuers having to process many different information chains occasionally neglect to forward important information to the map plotter. This renders the situation map not only inaccurate but also out of date.

In our preliminary experiment (Gunawan, Oomes, Neerincx, et al., 2009), an explorative study of collaborative map-making, we found that during the discussion while making one collaborative map, participants often expressed their confidence about objects and events they communicate about in the scenario. We also observed information-lost problem where in some cases, participants who were quite confident about a particular event gave up their stance, because the uncertainty of the other participant dominated the discussion.

Therefore, in this paper we further investigate whether collaboration using a shared situation map, or shared situation map accompanied with voice communication, can improve the effectiveness of a collaborative map-making task. Furthermore, by making the confidence information explicit, we can study whether it helps the participants during a discussion process so that they do not need to express their confidence all the time, and additionally due to its explicitness, it may even prevent valuable information from being overwritten.

EXPERIMENTAL METHODOLOGY

To assess the effectiveness of our proposed solution, we ran a controlled laboratory experiment that had two purposes: (1) measure the effectiveness of collaboration using a shared map and being complemented by voice communication (2) examine the potential influence of the availability of confidence information during the process of collaborative map-making.

Preparations

Two disaster scenarios were created using a slideshow showing pictures of a simulated disaster situation. Furthermore, to help participants to report on the disaster, they used a template map and a set of icons, representing objects and events which they could place on the map. These are explained below in further details.

Scenarios

In order for participants to be able to make a collaborative map with overlapping information on the same incident situation, we created two different scenarios needed for our experiment design. These two scenarios were an explosion in a gas station and a collapsed bridge due to collision. The scenarios were verified for their plausibility by a fire-fighter commandant. Each of the scenarios was divided into two parts: the accident unfolding and the rescue response. So at the end, we have four sets of stories.

The explosion scenario starts with a man filling his truck at a gas station. A spillage of gasoline from the gas tank is ignited by a lit cigarette bud. The ignition causes the truck to explode generating flames that engulf the truck, man, and gas station (as shown in Figure 1).

Figure 1. A picture from the explosion scenario showing the flames consuming the truck, the victim, and the gas station.

In addition, the explosion injures a boy playing near the gas station. While bystanders try to rescue the boy, flames spread to a neighbouring building trapping a girl in an upper level. When the fire trucks arrive they focus their efforts on rescuing the boy and trapped girl. The man who was tanking his truck receives a lower priority since he has already died from his injuries. Rescuing the trapped girl requires a fire engine with a turntable ladder since she is located in the 3^{rd} story of the apartment building. Finally, the little boy is taken away in an ambulance, the girl is rescued, and the fire is put out.

In the collapsed bridge scenario, a fire starts in a two-story house trapping a woman on the second floor. The commotion caused by the fire distracts the crew operating a freight boat cruising in a nearby water channel. As a result, the freight boat collides with a bridge sending a car with its driver into the water channel (Figure 2).

Figure 2. One of the images of the collapsed bridge scenario, showing the freight boat colliding with the bridge causing it to collapse.

After navigating around a traffic jam caused by the collapsed bridge, fire fighters put out the flames in the burning house and rescue the trapped woman. Meanwhile the driver who fell into the water channel is lifted to safety with the help of a fire engine with a turntable ladder.

The miniature world for incident setting

After creating the two scenarios, we constructed the disaster settings in which the scenario took place. Making incident scenes in the real world setting is not practical due to time and budget considerations, we therefore, decided to make a miniature world to simulate the incidents with Playmobil toy sets. These toys were chosen due to their simplicity and flexibility, which made them practical for the purpose of this experiment (Gunawan et al., 2009).

The scenes were constructed in such a way that they could be viewed from two different angles representing two different vantage points of the observers. Photos were taken from two specific locations, while the Playmobil model was adjusted as the accident storyline developed. We ended up with two sets of photo slideshows for each scenario, giving us four slideshows in total. For each scenario the first slideshow presents the story of the unfolding accident while the second shows the rescue effort. Some of the images were later manipulated using Adobe Photoshop to add effects such as fire and smoke.

The magnetic board for map-making

To allow the participants to rapidly create the situation map, and in an effort to ensure that the map can be consistently translated into quantitative data, we decided not to ask the participants to draw their recollection of the events on a piece of paper as in our previous study. Instead, sets of icons of the objects, actors, confidence level, and a map of the environment were given to the participant. As shown in Figure 3, participants were able to use these icons to illustrate their recollections of the events on a top view map of the disaster area. Since the map was fixed on a magnetic board, it was also possible to edit the locations of icons after they were placed on the map. This also gave the participants the ability to quickly edit the map if they wanted to. The board was light and simple to handle making it easy to hold it up right to face the camera, photograph the map and share it with the other participants.

Figure 3. A participant placing the icons on the magnetic board.

Participants

This study involved 32 participants that were grouped into pairs, thus in total we had 16 pairs. The pairs were arranged in such a way that each team consisted of unacquainted partners, to simulate that they have never worked together before as is characteristic during disaster. There were 7 female and 25 male participants, who were 22 to 42 years old ($M = 28$, $SD = 4.26$) with undergraduate to post-graduates level of education. The participants had a wide variety of different nationalities, and were recruited from the Faculty of Electrical Engineering, Mathematics and Computer Science at the Delft University of Technology. Only two out of 32 participants had special training or experience as rescuers. This composition represents the high ratio of affected people compared to rescuers. Additionally, they all had normal or corrected-to-normal eyesight.

The participant received a token gift as an incentive to take part in the experiment which took approximately 2 hours to complete. The available gifts they could choose from had a value of about €15.

Design

We used a two-way repeated-measures design where the within-subject factors were the type of collaboration (without collaboration, map sharing collaboration, map sharing with voice communication) and the availability of confidence level information (without confidence and with confidence). We counterbalanced the order in which the scenarios were shown and the availability of the confidence information. It was however not possible to show the rescue slideshows before the accident slideshows, this aspect of the experiment was therefore not counterbalanced. The same is true for the order of collaboration modalities between the two participants (individual maps, shared maps, then shared maps with discussion).

Procedure

Each experiment session was conducted with a pair of participants. We first explained the procedure of the experiment to the participants after which they were guided to separate rooms. Each participant read and signed a consent form that explained how the results of the experiment would be used. After completing a colour blindness test the first of four sessions started. In each session, the participants went through the task of constructing a situation map in three different modes of collaboration (no collaboration, shared map, shared map with voice discussion) explained in further detail in the Tasks section below. After finishing all four sessions, the participants filled in a final questionnaire giving their impressions of the experiment.

Tasks

In each session, a slideshow was shown to the participants depicting the events for one of the scenarios. Each slideshow consisted of 21 slides, and each slide was shown for 5 seconds. The order of the scenarios was counter balanced, however the slide show of the accident events always preceded the rescue slideshow. Each of the two participants saw a slideshow of the same events but from a different point of view. After viewing the slideshow, participants were given the magnetic board with the top view map of the disaster area and were asked to reconstruct the events they just saw on the map.

In the ‘with confidence information’ condition, the participants were asked to add their confidence level for all events, actors, and vehicles involved in the scenario. They could rate the confidence with a red star for ‘low confidence’, yellow for ‘medium confidence’, and green for ‘high confidence’. Participants could place these stars next to the icons they placed on the maps, as shown in Figure 4.

A photo was then taken of the magnetic board and shown to the other participant, representing a shared map. The participants were given the chance to adjust their results if they felt necessary.

Finally they were again shown the map of the other participant and given the chance to have a voice discussion with the other participant for a maximum of 5 minutes. During or after the voice discussion the participants could adjust their map. A final photo was taken of the maps for evaluation purposes.

This was followed by three more sessions involving the rescue slideshow of that scenario, and the accident and rescue slideshows of the other scenario. In each of these sessions, the pair of participants went through the three above mentioned stages of collaboration. When starting to construct the map for the rescue session, the participants were given the choice to either modify the map they created for the accident slideshow or clear the map and start constructing a new one.

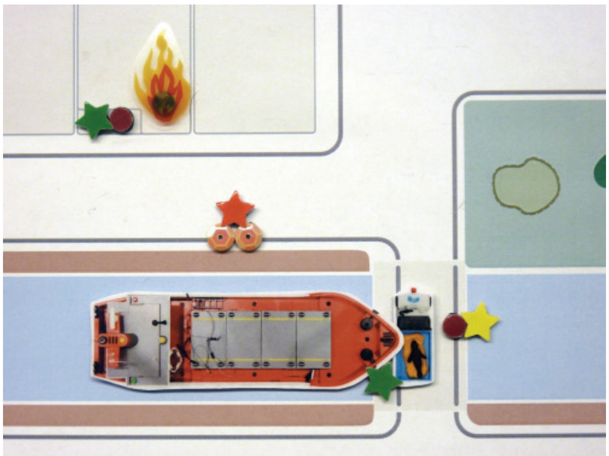

Figure 4. A participant’s map with confidence level next to the objects in the map. This map shows, for example, that the participant was sure about the collision between the cargo boat and the small truck, but has low confidence that there were two helping bystanders.

Measures

Our main goal for this study was to examine the effect of the collaboration types and the availability of confidence information on the collaborative map making. We studied this by analysing the following three measures: the quality of the map, the behaviour of the participant in the discussion, and the perceived usefulness of confidence information.

The quality of the map was measured by comparing them to an ideal key map that contained all the events in the slideshows. Furthermore, we recorded the discussion data where the participants collaborated with voice communication. Finally, the perceived usefulness of confidence information was collected by using a post-questionnaire at the end of the experiment.

RESULTS

Data Preparations

For assessing the map quality, first an ideal-map was produced based on the ideal recreation of the events shown in the slideshows. The maps created by the pairs were evaluated by comparing them object by object to this ideal-map. Each object had two properties to be rated, namely detection (whether it was detected and placed on the map) and location (whether it was placed on the correct location). Each property received a score that could either be 0 (completely wrong), 0.5 (partially correct), and 1 (an exact match of the key-map). The ratings is 0, for example, when the location is completely not corresponding to the one in the ideal map, while the 0.5 ratings is given when it is close to the correct location, indicating that the participant has an approximate idea regarding the location of the event.

Objects were then tagged into categories to facilitate further analysis of the data. For example, it was possible to analyse the quality of vehicles mapped by looking at the score of all objects with the vehicle tag (police cars, fire trucks, cars involved in the accident, etc.). The score for this category was calculated by taking the average score from all vehicles. When calculating the general quality of the entire map, the average score was taken of all objects on the map (there were around 68 objects). This average score was an interval value ranging from 0 to 1.

In preparing the voice discussion data, first we developed a coding scheme specific to the recordings. We first listened to all the discussion recordings, 4 sessions in each experiment x 16 pairs of participants x max 5 minutes discussion, so in total we listened to around 320 minutes (around 5 hours) of discussion recording. While we listened to these recordings, we noted down important keywords on post it notes, after this we clustered the post-it notes to find the important phases and events in this specific discussion process. We defined six mutually exclusive phases and five events that were not mutually exclusive. The five different phases are: (1) communication, (2) meta-communication, (3) my story, (4) your story, (5) bargaining, and (6) conclusion. The communication phase is where the participant greet each other, give compliments, and say goodbye. While the meta-communication phase is a phase where the pairs communicate on how they should communicate in this discussion, such as discussing their working procedure, suggesting procedure, and explaining what they are doing. Telling each other's story consists of two sub-phases 'My Story' is where participants talk about their point of view and 'Your story' is where they talk about (what they think is) the other participant's point of view. This is the phase where the participants exchange, compare, and discuss the differences in their map. Bargaining is the phase where the pairs discuss their findings, such as trying to convince the other participant and give suggestions of solutions. Finally, the conclusion phase is when the pairs conclude and summarized the agreements.

The five events we defined are: (1) referencing the map, (2) certainty, (3) uncertainty, (4) agreement and (5) disagreements. Referencing the map involves talking about the map itself while certainty and uncertainty refers to the moments where any of the participants are talking about how confident they are of certain events. Lastly, agreement and disagreement cover moments where the participants are in agreement or disagreement with each other. Since these events are not mutually exclusive neither to each other nor to the mentioned phases, more than one event can occur in the same time. This can happen, for example, if the participants express their disagreement about their map while in the bargaining phase.

Furthermore, using a custom built annotation program, and an annotator who were not involved in the study to annotate the 320 minutes of data recording with all the phases and events we came up with. The discussion duration and frequency for each session and scenario was then calculated. Durations were only calculated for phases and not the events. These were calculated by summing up the durations of all segments of the discussion spent on a specific phase. The frequency (of the phases and the events) refers to the number of times they were initiated during the discussion. Furthermore, the duration data was logarithmically transformed, $\log_{10}(x+1)$ to decrease the effect of outliers and extreme values.

To meet the independent sampling assumption, all analysis had to be done on a pair level. Therefore, all data such as the map quality, the discussion duration, and the post questionnaires was averaged for each pair.

Statistical Analyses

Map quality

The quality of the map was tested using a MANOVA. The independent variables were the availability of confidence level indicators and the type of collaboration (with no collaboration, shared-map collaboration, shared-map with voice communication collaboration), while the general map quality was the dependent variable. The result showed that the type of collaboration had a main effect on the quality of the map with $F_{2, 14} = 57.13$, $p. < 0.001$. This main effect was also found consistently in the analysis of the individual categories such as the victims, vehicles, etc., both on the accident map and the rescue map. This collaboration effect is illustrated in Figure 5, which shows that with more collaboration the quality of the map improved.

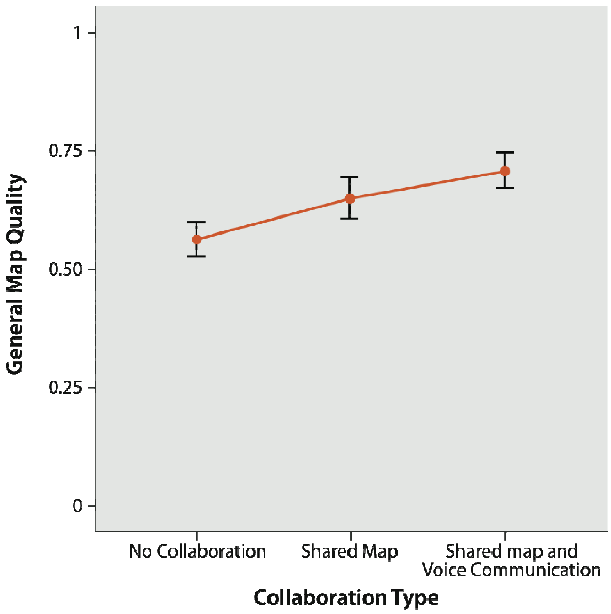

Figure 5. The mean map quality with 95% confidence interval.

The analysis did not find a main effect for confidence level availability $F_{2, 15} = 0.02$, $p. < 0.884$ or an interaction effect between collaboration and the availability of confidence level $F_{2, 14} = 1.56$, $p. < 0.244$.

Voice Discussion

We analyzed the voice discussion data in two ways. First is the total duration for each of the phases and secondly the frequency of the events.

To analyze the voice discussion duration, we used a two-way repeated-measures MANOVA. The session (accident and rescue session) and the availability of confidence information were the independent variables, and the discussion phases (Communication, Meta-communication, My Story, Your Story, Bargaining, and Conclusion) were the dependent variables that were analyzed separately for each phase. The test revealed that the availability of confidence information had a significant effect (a main effect and an interaction effect) only on the conclusion phase of the discussion. The main effect found, $F_{1,14} = 5.31$, $p. = 0.037$, showed that the duration of the conclusion phase in the accident session became shorter when the confidence information was available.

Additionally it also showed a significant two-way interaction effect between session and the availability of confidence information $F_{1,14} = 6.89$, $p. = 0.02$, as shown in Figure 6.

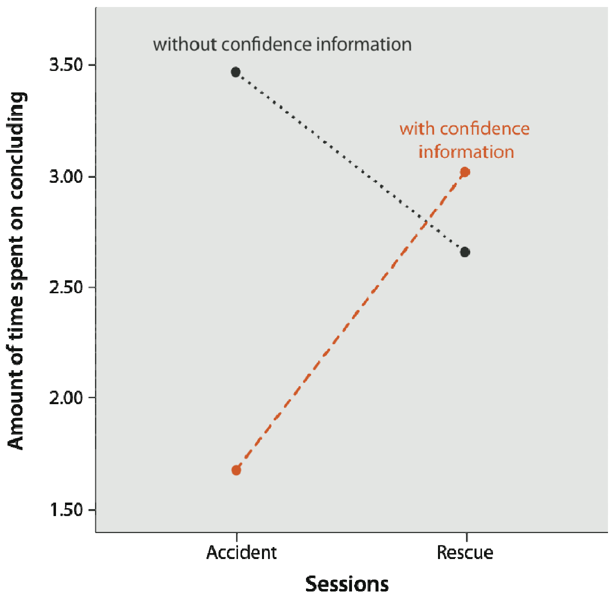

Figure 6. The effect of the availability of confidence information on the duration of the conclusion discussion during the accident and rescue sessions.

A detailed analysis of this interaction effect using a paired-sample *t*-test showed that participants took less time in concluding when the confidence information was available in the accident session ($t_{14} = 3.19$, $p. = 0.007$). However, this effect was not found in the rescue session ($t_{14} = -0.77$, $p. = 0.455$). Furthermore, without the confidence information, the time duration spent on concluding the discussion showed no significant time decrease between the accident and rescue sessions ($t_{14} = 1.86$, $p. = 0.085$), while it showed a significant increase in time when the confidence information was available ($t_{14} = -2.62$, $p. = 0.02$).

The frequency of each of the 5 events in the discussion was analyzed using a Wilcoxon signed-rank test. From the 5 tests that we did only one event (namely the uncertainties) showed a significant ($Z = -2.575$, $p. = 0.01$) frequency difference as a result of the availability of confidence information conditions. There was an increase in the frequency of the uncertainties event in the discussion. In other words, when the confidence information was present, the uncertainties were mentioned more often. This may be due to the fact that the test participants articulate more of their uncertainties when it is explicitly represented on the map. However, without confidence level, the uncertainties were less frequently discussed.

Post Questionnaires

At the end of the experiment, participants were asked to rate the perceived usefulness of the confidence level information during their process of collaborative map-making on a 7-point rating scale. A one-sample *t*-test with test value = 4 (we assume here that 4 is the neutral ground between positive and negative attitude) showed a significant ($t_{15} = 2.93$, $p. = 0.01$) deviation from this middle rating. Looking at the means response, of 4.97, this suggested that participants lean toward a positive attitude towards this feature. From this, it seems that participants on average were in favour of the confidence information.

LIMITATIONS

One important limitation of this study is the potential learning effect between the collaboration conditions. However, for practical reasons, this could not be counterbalanced. It is less useful for the participants to have a discussion first then break up and make the map based on the discussion. The findings of then increase in map quality improvement over the different types of collaboration may therefore be partly explained as a learning effect. Future research can further investigate this effect, perhaps by designing the experiment using a between-subject design with one group getting a condition of no collaboration and shared map collaboration, and the other group getting a condition of no collaboration and shared map with voice communication.

A second limitation is the lack of a practice session which may have had a negative influence on participants' performance in the first session (e.g. because of unfamiliarity with Playmobil forms and colours). In retrospect, it seems evident that a practice session would have helped reduce such an effect. On the other hand, by taking into consideration that each complete experiment session took the pair of participants approximately two hours to complete, it would have been difficult to add extra components to the experimental setup.

DISCUSSION

Although we found that confidence level affected the discussion process and the participants were in favour of this feature, we did not find an effect for it on the quality of the map. This may be caused by confusion over how to use this confidence information in the map-making process. In fact, it can be interpreted in two different ways, whether it was confidence for the type of the object, or the confidence information for the location of the object. It is also possible that participants liked the confident information because it helped the discussion process run smoothly.

The novel use of toy sets, Playmobil, as quick prototyping tools for depicting disaster scenarios served the purpose of our experiment well. Surprisingly, consultations with a fire-fighter commandant revealed that Playmobil was also used to train the fire-fighters during their exercises, where the toys were used to model disaster situations that fire-fighter trainees should understand and use to plan their actions.

CONCLUSION

This paper presents the findings of an experiment that investigates the effect of indirect collaboration by sharing a map with or without voice communication and the effect of the availability of confidence information on the process of collaborative map-making.

We learned that during collaborative map-making, it is useful to enable indirect collaboration of sharing a map made from different viewpoints since it improved the quality of the map. This quality can be further improved by bridging the communication between the collaborators in addition to the shared map using voice communication. Furthermore, supporting the collaboration by providing confidence information can shorten the conclusion phase of the discussion process. Next, during the discussion, uncertainties are more often expressed when the confidence information is available. Additionally, the confidence information was also well received by the participants.

The collaboration and the confidence information may help the process of situation-map making, however, both ideas need to be implemented as a technological solution. As future work, the implementation and evaluation of these ideas will be our next step. The evaluation hopefully, can be done in a more realistic setting. We will also ask for opinions from experts in the field. Furthermore, we want to integrate this effort with our previous research (Gunawan, 2008; Gunawan, Oomes, & Yang, 2009), where victims who need to be guided to a safer place, can also benefited from the constructed situation map.

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