Supporting controversial CSCL discussions with augmented group awareness tools

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Abstract: An experimental study investigated the influence of an augmented group awareness tool on controversial online discussions and decisions made by 4-person learner groups. The study employed an informed minority paradigm where one group member holds a correct viewpoint, but is faced with a 3-person majority holding an incorrect viewpoint. Within this paradigm, groups using an augmented group awareness tool based on learner ratings of agreement and novelty of contributions were compared to groups using a standard online discussion tool. It was shown that majority influence occurred in unsupported groups, whereas augmented group awareness tools strengthened minority influence, as indicated by group decisions and individual correctness of decisions.

Introduction

Since the early 1990s the notion of awareness has figured quite prominently within the field of CSCW (computer-supported cooperative work). The concept of awareness is rather vague, but there is some agreement that it refers to the perception and knowledge of contextual variables about the material and social world that surrounds a person or a group (Endsley, 1995). This paper seeks to empirically explore the question whether the concept of awareness can be fruitfully adapted and applied to the field of computer-supported collaborative learning (CSCL).

There is a huge diversity of how the term awareness is employed in the literature, and several attempts have been made to categorize this field (e.g. Carroll, Neale, Isenhour, Rosson & McCrickard; 2003; Christiansen & Maglaughlin; 2003; Gross, Stary & Totter, 2005). For the purpose of this paper it is sufficient to state that we make a distinction between situational awareness (knowledge and perception about the material environment surrounding a person) and group awareness (knowledge and perception about the social environment surrounding a person). This paper involves an inquiry into group awareness, i.e. knowledge and perception about the presence, the activities, and the products of other persons in a collaborative setting.

Group Awareness

Group awareness is comprised of several elements, among them knowledge and perception of who is there, where other persons are located, where they are looking at, and what they are doing (Gutwin & Greenberg, 2002). It is evident that group awareness is easily available in face-to-face (FTF) scenarios. However, once group members are spatially separated, group awareness has to be facilitated by means of technological support. Consequently, the use of group awareness technologies has become widespread in digital environments, ranging from lists of active users in online discussion forums (who is there) over avatar embodiments in virtual environments (where are they located, where are they looking at) to video screens, shared scroll-bars in collaborative editors, activity indicators, timelines, and other widgets used in shared workspaces (what are they doing).

Against this background our own research on group awareness and development of group awareness tools departs in two directions. Our first extension of group awareness refers to the type of information that participants receive about their group. Group awareness is a natural by-product of FTF interaction. Consequently, many CSCW approaches try to re-establish FTF conditions by technological means. Most examples of group awareness tools refer to information about the group and its members that would be easily available in FTF settings (e.g. seeing who is there, seeing what others are doing). While providing FTF-like conditions by technological means is a legitimate goal for systems designers, we would argue that the true power of technological support can be shown only if technologies give rise to kinds of interaction that actually surpass FTF levels to some degree. The focus of our own research therefore is on augmented group awareness tools that provide information that would be difficult or impossible to yield in FTF interaction. More specifically, our tools are designed to provide information about entities having no physical equivalent, e.g. on non-observable psychological constructs like knowledge, attention, attitudes, preferences, or emotions.

The principle of augmentation is far from novel. Therefore, our own research draws heavily from work in the field of social navigation (Höök, Munro & Benyon, 2002). Social navigation describes the various influences that the visualization and feedback about other users' behavior has on the navigational behavior of an individual. Many forms of social navigation focus on so-called recommender systems where an individual's choices are informed by recommendations of other persons. Social navigation can either be direct (i.e. users explicitly rate certain items which leads to recommendations for other users), or it can be indirect where the online navigation of users will be captured in order to gain information about their preferences. The latter method is popular in online book stores where products will be recommended on the basis of the purchasing behavior of customers who bought the product one is currently inspecting. Augmented group awareness tools employ social navigation principles (e.g. taking user ratings about non-observable entities) and combine them with group awareness principles. E.g., unlike in social navigation the information will be collected from group members one is actually interacting with, rather than from an anonymous collective. Moreover, the provided information does not refer to external products like books, but to products created by the particular group one is belonging to, viz. their discourse contributions. In this respect augmented group awareness tools are a hybrid between social navigation tools and classical group awareness tools.

A second extension of classical group awareness research that our work is exploring relates to the application of augmented group awareness tools to the field of CSCL. Very few attempts have been made in this direction, and the few applications in this field either focus on observable entities like learner activities (thus being classical group awareness tools) or provide information for the observing scientists rather than the group itself (cf. Jermann et al., 2001, for an overview). It is an open question whether groups make use of awareness-related information, how they use it, and if the use reflects in different kinds of group behavior. In any case augmented group awareness tool provide a somewhat novel technology metaphor. While some CSCL approaches use technology as an unstructured medium (potentially leading to learner disorientation), and while other approaches rely on rather directive means of structuring collaboration (potentially leading to overscripting; Dillenbourg, 2002), augmented group awareness tools provide a middle ground between these two extremes. They are designed to engender completely autonomous, but well-informed learner actions.

We have set out to explore the use and usefulness of augmented group awareness tools for collaborative learning scenarios. Our current work focuses on a general group awareness tool that is designed to support both synchronous and asynchronous forms of online group discussions. The basic idea here is to require learners to rate the written contributions in an online discussion on one or more dimensions. The tool itself performs the functions of a) taking the learner ratings as input; b) aggregating and/or transforming these inputs; and c) visualizing and feeding back transformed contextual variables as graphical output to the group. In this way learners are informed about the current state of the group with respect to some contextual variables in real-time.

Minority Influence in Collaborative Learning

In order to test the usefulness of these augmented group awareness tools we applied them to a particular scenario of collaborative learning, viz. the case of controversies and conflicting viewpoints. According to educational theorizing, controversies and conflicts are often seen as important antecedents of collaborative learning (Doise & Mugny, 1984). Some collaborative learning methods are even specifically tailored to engender a controversial discussion among learners, e.g. Structured Controversy (Johnson & Johnson, 1992). Despite the potential of controversies to facilitate elaboration of and negotiation among learners, there might be some pitfalls to these methods. The social psychological research literature points at various deficiencies of controversies because they can give rise to patterns of social influence that might be detrimental to a group's functioning, particularly if the sub-groups advocating the viewpoints are of different size. For instance, there is an abundance of social psychological literature that points at the difficulties that minorities in a group have on influencing conflicting majority viewpoints (Asch, 1956), especially if the task at hand is not demonstrable (i.e. a particular viewpoint cannot easily be proven to be a correct one). If this robust finding is applied to collaborative learning one can only assume that controversial discussions in a learning domain are also prone to the influence of a majority, irrespective of the validity or justifiability of the majority viewpoint. Generally, the suppression of minority viewpoints would be detrimental to collaborative learning because it prevents groups from gaining divergent, flexible perspectives on a particular domain. These detrimental effects of lacking minority influence are even exacerbated when the minority holds a scientifically correct viewpoint that fails to influence an incorrect majority perspective. Given that collaborative learning requires the joint construction of a shared understanding it could well be the case that in such a scenario the minority would rather comply with the incorrect majority perspective than vice versa.

In the context of group-decision making these patterns of social influence are often investigated in a quantifiable manner by employing so-called hidden profiles (Stasser & Titus, 1985) with an informed minority. In these scenarios a minority group member receives unshared, critical information that should lead to a different, but better group decision quality than the shared pieces of evidence that the majority members receive. In addition to the general finding that groups are often unable to uncover a hidden profile (i.e. identifying the best alternative) studies employing an informed minority have shown that groups focus less on critical (minority-held) information when the task did not appear to be demonstrable (Stewart & Stasser, 1998), that minority influence was even diminished when groups were using an anonymous group decision support system (McLeod, Baron, Marti & Yoon, 1997), and that the discovery rate of the best decision alternative (out of three) was only 10% using an informed minority (Brodbeck, Kerschreiter, Mojzisch, Frey & Schulz-Hardt, 2002).

However, social psychology has also outlined several conditions that should lead to enhanced minority influence. These beneficial principles are important because they informed the particular design of our augmented group awareness tool. For instance, it was reported that minorities exert more influence over majorities if they appear consistent in their argumentation even in the face of controversy (Moscovici, 1976). If members consistently perceive that there is a conflict in the group, efforts to resolve conflict and seek for a resolution are likely to be maintained rather than ignored. A second important antecedent for minority influence stems from the theoretical distinction between normative and informational influence (Deutsch & Gerard, 1955). The influence of a majority on the minority is normative, i.e. minorities often conform to the majority viewpoint because of social pressure. The influence that a minority can have on the majority, however, is usually informational influence, i.e. majorities will be more likely to conform with a minority viewpoint if the arguments brought forth by the minority are particularly persuasive. Similarly, Nemeth (1986) has reported that a key factor in minority influence is the potential novelty of the arguments brought forth.

The design of our augmented group awareness tool for the informed minority scenario was building on these principles via two mechanisms. First, group members were required to rate their agreement with a given contribution. Because one could expect that average agreement with minority contributions is lower than for majority contributions, the visualized arithmetic means of agreement ratings should visually separate majority and minority contributions. This would serve as a constant reminder to the group that a conflict might still exist between viewpoints, thereby precluding false consensus. Moreover, this visual separation of contributions should enhance the consistency of the minority viewpoint. Second, group members were required to rate the novelty of a given contribution. Here one could expect that the novelty of majority contribution is rated as relatively low (because majority arguments are shared, and tend to be redundant), whereas minority contributions should yield high novelty ratings. By emphasizing on the redundancy of contributions by a majority its normative influence might be decreased, whereas informational influence of the minority should be increased by focusing on their novelty. Thus, by making the unique contributions of a minority salient, it was expected that their influence on the (incorrect) majority viewpoint would be increased. A specifically designed group awareness tool requiring ratings of agreement and novelty should therefore lead to strengthened minority influence. This should be reflected in better group discussions, and due to using an informed minority paradigm lead to better group decisions and learning. This hypothesis was explored in an experimental study.

Method

In the study, small groups of four learners used a text-based online discussion environment in order to come to an agreement on a conflicting physics topic. Similar to the *informed minority* paradigm (Stewart & Stasser, 1998), learning material, consisting of pieces of evidence, was previously distributed across the group members in such a way that one learner – the informed minority – received information that should lead to a scientifically correct viewpoint on the issue, whereas three other learners (majority members) received information that should lead to a plausible, but incorrect viewpoint.

Design

Two experimental conditions were compared that differed with respect to the support learners received regarding the awareness of other group members' contributions during the online discussion. While learners in the control condition were only provided with an online discussion environment, learners in the treatment condition were additionally provided with a rating-based augmented group awareness tool.

Participants

64 students (26 males and 38 females, ages 19 to 31; *M = 22.05; SD = 2.35*) at the University of Tübingen were randomly assigned to the two experimental conditions and – within the small groups – to the minority or to the majority. They were paid for their participation. To prevent a very high level of prior knowledge physics students were excluded from participation.

Materials

The application domain was comprised of physics concepts concerning light propagation.

The instructional material was taken from the web-based inquiry science environment WISE module "How far does light go" (Bell, 1995). The entire pool of learning material consisted of six pieces of evidence concerning light propagation. Two pieces of evidence were in line with a scientifically plausible, but incorrect viewpoint ("Light dies out"), whereas three pieces of evidence were supporting the scientifically correct viewpoint ("Light goes forever"). A sixth piece of evidence was irrelevant with respect to the conflicting viewpoints. The six pieces of evidence were distributed across the group members prior to the group discussion according to the informed minority paradigm of Stewart and Stasser (1998). The three majority members received four pieces of evidence each: two (shared) information pieces supporting the incorrect viewpoint; one (unshared) information piece about the correct viewpoint; and the irrelevant piece of evidence. Taken together, the information distribution in the majority was identical to a hidden profile, i.e. each member would be more likely to prefer the incorrect alternative based on shared information, whereas a group's preference should shift towards the correct alternative if the unshared information pieces were pooled during discussion. The fourth member of the group (informed minority) received all six pieces of evidence which should lead to a preference for the correct viewpoint. Prior tests revealed that this type of information distribution predicted learner preferences quite accurately, i.e. independent learners who received the same material as the minority, tended to favour the correct viewpoint, whereas learners who received the same material as the majority, were biased in favour of the incorrect viewpoint.

The online discussion environment used in both experimental conditions was developed at the Knowledge Media Research Center in Tübingen as part of the groupware system VisualGroup (in its current version renamed as Bebop). It enabled the small groups to discuss in a text-based and synchronous way. Contributions were listed sequentially in temporal order. To control for effects of acquaintance among participants actual names were replaced by neutral handles ("person A" etc.), i.e. contributions were made anonymously. *The group awareness tool* provided to the small groups in the treatment condition was embedded into the online discussion environment. It consisted of (1) seven-point Likert rating scales that allowed learners to rate each contribution (except their own) with respect to (a) the agreement with a contribution, and to (b) the novelty of a contribution in the discussion, and (2) a visualization of the contributions represented as dots on a two-dimensional graph, where the x-axis represented the average agreement rating, and the y-axis represented the average novelty rating that a given contribution received. The visualization was personalized in that learners could distinguish their own contributions from other group members' contributions, and by indicating contributions a learner hadn't rated yet (Figure 1). By clicking on a particular dot in the visualization learners could read the corresponding contribution.

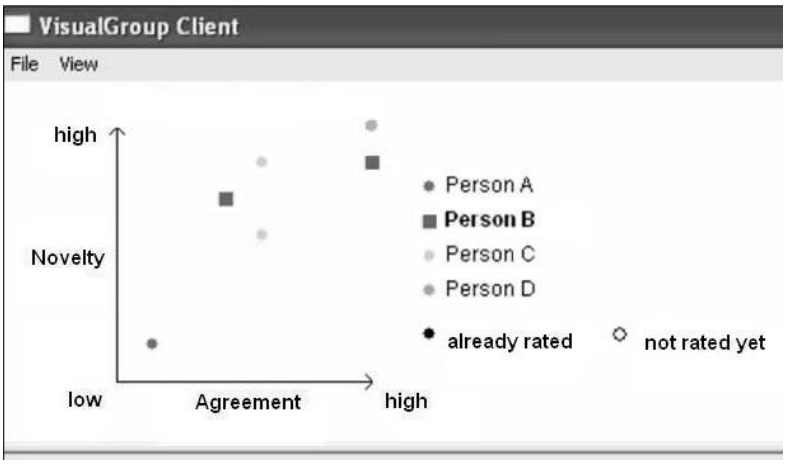

Figure 1. Screenshot of the visualization used (translated from German).

The test material for assessing the knowledge of the learners consisted of two test sheets that were individually administered before and after group discussion. The first test sheet required participants to state their preference for one of the two controversial viewpoints, and to indicate their confidence with this rating. The second test sheet which was administered after the discussion asked learner to state the decision that the group arrived at. Moreover, learners were required to indicate their individual preference for one of the controversial viewpoints, and a confidence rating for the individual decision.

Measures

Group decisions (correct vs. incorrect decision) were extracted from the contents of the group discussions. Since subjects were also individually required to explicitly state the group decision after the discussion, these data could be used in cases where the actual group decision was not evident. It was expected that groups in the treatment condition would make better group decisions than groups in the control condition.

Measures of learning were derived from the decisions among the two conflicting viewpoints that both the groups and the individuals made after discussion. In order to gain access to a rough indicator of individual learning the preferred decision alternative and the confidence ratings were used to calculate a correctness value of the decision ranging from 0% (wrong answer and confidence rate of 100%) to 100% (correct answer and confidence rate of 100%). It was expected that in treatment groups (with augmented awareness tool) minorities would exert a greater influence on the group decision, thereby yielding higher correctness values across group members.

Discussion parameters were derived as indicators for knowledge building processes. Log files of the discussion contents were used to generate general measures of participation (e.g. number of written contributions). The discussion content was additionally coded by two independent coders. Single contributions were rated according to three categories (knowledge construction; negotiation of preferences; others). It was expected that groups in the treatment condition would display a lower number and rate of contributions rated as negotiation of preferences because the visualization already contained the corresponding information. As a consequence, it was tentatively hypothesized that this might lead to a higher number and rate of knowledge construction contributions. On the level of the whole group discussion sessions independent coders additionally categorized the deliberation style of groups. Deliberation style is a concept drawn from research on mock juries. E.g., Hastie, Penrod and Pennington (1983) have found that some juries discuss evidence-driven, i.e. they start by exploring the evidence before integrating the evidence into a verdict. Other groups, however, are verdict-driven, i.e. they start by collecting and integrating individual verdict, and then start a (biased) search for information in support of this verdict. It was expected that without augmented group awareness tools groups might be tempted to reach a consensus overly quickly, thereby employing a verdict-driven style. Due to the small sample size deliberation style of groups was only analyzed in descriptive terms.

Procedure

The experiment consisted of two phases: an individual learning phase, and a group discussion phase. During the entire experiment subjects of a group were seated in separate rooms. In the first phase learners received information about light propagation individually (10 minutes). While the information distribution was identical across conditions, it differed within the small groups according to the informed minority paradigm of Stewart and Stasser (1998), as described above. Subsequent to the individual learning phase, but prior to the group discussion, individual preference and confidence were measured. After the learning phase individual group members were given the opportunity to test the online discussion environment by writing contributions. Group members in the treatment condition were additionally asked to rate test contributions by other participants.

In the second phase groups were instructed to discuss the conflicting viewpoints. All learners were made aware that other group members might have received different pieces of evidence. Groups were asked to make a decision about the conflicting viewpoints within the allotted discussion time (30 minutes). According to the experimental design of the study small groups in the control condition were only provided with the online discussion environment, while small groups in the treatment condition were additionally provided with the group awareness tool. After the discussion phase individual learners were asked to repeat the group decision, state their individual preference and indicate the confidence in their individual preference. Subjects were briefed about the study at the end of the experiment.

Results

Manipulation check

Across both conditions, all minority subjects showed a preference for the correct viewpoint, as indicated by pre-discussion choice. However, among the majority members only 41 out of 48 subjects chose the incorrect viewpoint. The distribution of pre-discussion choices between the two conditions was not different, i.e. out of the 7 subjects that did not adhere to the manipulation, 3 were in the condition without group awareness tool vs. 4 in the experimental condition, thus yielding no significant differences between conditions – ($\chi^2(1, N = 64) = .68$, n.s.). Although results using actual pre-discussion choice as independent variable were slightly more favorable with respect to the hypotheses, results described in this paper are based on the more conservative independent variable of member status (majority vs. minority), as intended by the manipulation.

Group decisions

Among the eight groups using the augmented group awareness tool, six arrived at the correct group decision vs. two for the incorrect decision. In contrast, groups without group awareness support arrived at the incorrect decision in six cases, at the correct decision in one case, while one group did not arrive at a conclusion during the allotted time. The difference in arriving at the correct solution is significant between conditions (χ^2 (2, N = 16) = 6.57, $p < .05$). This provides evidence that augmented group awareness tools were reversing the bias towards majority opinion.

Individual correctness

Table 1 shows the correctness values for minority and majority subjects within the treatment and control condition. A 2x2 analysis of variance (ANOVA) with support and member status as independent variables yielded a significant main effect for member status; $F(1,60) = 4.74$, $p < .05$. The main effect for support and the support x status-interaction approached significance ($p = .08$ in both cases). However, the data from Table 1 show that majority members in the treatment condition were scoring much higher than majority members in control groups. An additional, one-tailed t-test revealed that this difference was highly significant; $t(46) = 3.56$; $p < .01$. In other words, there is evidence for the hypothesis that majority members moved from the incorrect to the correct viewpoint if they were using an augmented group awareness tool.

Table 1: Individual correctness values for learners across member status (majority vs. minority) and support (treatment vs. control).

		Status		
Support		Majority	Minority	Overall
Control	M	37.17	78.63	47.53
	SD	36.89	32.51	39.76
Treatment	M	74.58	78.38	75.53
	SD	36.02	36.18	35.51
Overall	M	55.88	78.50	61.53
	SD	40.72	33.23	39.97

Discussion parameters

Table 2 shows the absolute number of contributions written by majority and minority members across the two conditions, separated by the three coding categories (knowledge construction, negotiation of preferences, other). Results of 2x2-analyses of variance (ANOVA) indicate that members from control groups wrote more contributions than group members in the treatment condition; $F(1,60) = 21.75$, $p < .01$. No differences were found for member status or the support x status-interaction. A main effect for support could also be found by only taking into account messages that were coded as knowledge construction contributions; $F(1,60) = 5.70$, $p < .05$. However, an analysis of relative amounts of knowledge construction messages reversed this effect; $F(1,60) = 6.49$, $p < .05$. In other words, treatment groups produced a higher relative amount of knowledge construction contributions than control groups ($M = .67$, $SD = .18$ vs. $M = .51$, $SD = .17$).

Table 2: Number of contributions across conditions that were coded as knowledge construction (KC), negotiation of preferences (NP), or others.

Support		Majority			Minority			Overall		
		KC	NP	Other	KC	NP	Other	KC	NP	Other
Control	M	9.37	4.67	3.63	10.63	5.13	2.63	9.69	4.78	3.38
	SD	6.11	2.76	2.00	7.33	4.49	1.92	6.33	3.20	2.00
Treatment	M	6.21	2.21	.50	7.00	3.00	1.38	6.41	2.41	.72
	SD	2.86	1.38	.66	2.27	1.93	.92	2.71	1.54	.81
Overall	M	7.79	3.44	2.06	8.81	4.06	2.00	8.05	3.59	2.05
	SD	4.98	2.49	2.16	5.56	3.51	1.59	5.11	2.76	2.02

The descriptive analysis of the groups' deliberation style indicated that seven out of eight control groups were following a verdict-driven style. Four of the treatment groups were using an evidence-driven style of deliberation vs. three verdict-driven groups. The remaining two groups in both conditions were not uniformly classified among raters. In others words, a deliberation style that started with collecting evidence before arriving at a decision was only to be found in treatment groups. Additional analyses revealed that all four evidence-driven groups, the two mixed-style groups and only one of the verdict-driven groups arrived at the correct group decision. In contrast, all verdict-driven groups made a decision in favor of the incorrect majority viewpoint.

Discussion

An experimental study showed that group using an augmented group awareness tool showed a higher performance in terms of group decision and individual correctness than unsupported discussion groups.

On a larger scale addressing the entire CSCL community one of the most interesting findings of the study was the fact that majority influence indeed occurred in the unsupported control groups. It was often mentioned that CSCL tends to look at positive results, thereby neglecting instances where collaborative learning might actually fail. Our studies have shown that in learning scenarios social psychological factors like majority influence are at work. While this might not be surprising to social psychologists, this point is hardly addressed in the CSCL literature. We hope that in the future findings from social psychology will be merged with findings from CSCL, thereby arriving at a clearer picture of collaborative learning.

While it appears that collaborative learning groups might arrive at suboptimal solutions because of an overpowering majority influence, our experiment indicated that this inherent bias can be overcome by technological means. An augmented group awareness tool specifically designed to focus on learner ratings of agreement and perceived novelty significantly increased minority influence, thereby leading to better group and individual learning performances. Of course, in natural learning settings it is not always the case that a correct minority is facing an incorrect majority. However, it can be expected that minority viewpoints frequently occur, and they tend to be overlooked, irrespective of their correctness. Therefore, augmented group awareness tools should contribute to a more thorough consideration of diverse viewpoints, a goal that probably aligns with a huge range of CSCL accounts. The benefit of allowing for diversity was also illustrated in our analyses of deliberation style. Whereas control groups were frequently focusing on finding an initial verdict, followed by identifying supporting evidence, it appears that the augmented group awareness tool used in the treatment groups led to a much more open, evidence-driven discussion before groups settled on a decision.

Although outcome measures indicate differences between conditions the more general question of what mechanisms might have produced the obtained results were not explicitly addressed thus far. In other words, what parts of the augmented group awareness tools were conducive to strengthened minority influence? On the one hand, simply requiring learners to rate contributions might lead them to reflect on the content, to serve as a metacognitive prompt, and thereby leading to minority influence and better learning outcomes. This potential effect would hold even in the absence of a visualization. On the other hand, the visualization might exert specific influence on learner behavior by making aspects of collaboration particularly salient (e.g. novelty of a contribution), thereby guiding

learners' attention to relevant information. Of course, both mechanisms might as well work additively. We will test these two conflicting explanations in a follow-up study that includes a ratings-only condition. Another interesting question is what actually happens when a majority member shifts preference. Is it because convincing arguments were brought forward (content-related) irrespective of their source, or is it because these arguments were brought forward by a particular source (person-related). In our present experiment the identity of authorship was confounded with the content, i.e. contributions in the visualization were color-coded with respect to the authors. The follow-up study will disentangle these effects by either using a non-color-coded visualization of contributions (content-only), a visualization that only displays the group members as dots (person-only), or a combined visualization.

Future Directions

It is apparent that the augmented group awareness tool used in this study was specifically tailored to scenarios of majority-minority conflicts. However, it can be assumed that the general type of rating-based augmented group awareness tools can be adapted to other scenarios as well. For instance, other studies could investigate this tool not for group awareness, but for social navigation in a stricter sense by requiring learners not to mutually rate their contributions, but to rate external sources like learning materials. For other scenarios it might be suitable to visualize the given instead of the received ratings. Moreover, depending on the research question learners could rate contributions on different dimensions, e.g. liking, conclusiveness. The tool itself could use different means of aggregation and visualization. Whereas the tool in the current study was simply using arithmetic means of agreement and novelty, other tools could visualize standard deviations (an indicator of the degree of conflict), correlations, or even make use of advanced statistical procedures like cluster analysis and factor analysis in real time. Finally, it will be an interesting question to compare direct social navigation (explicit ratings) with indirect social navigation where learner behavior will be implicitly captured. In the social navigation literature indirect social navigation algorithms are often regarded as superior because they do not burden subjects with the potentially tiresome task of rating contributions. However, our discussion on the explanatory mechanisms for minority influence in this experiment might indicate that this additional burden might be a key factor in producing favorable learning results.

Conclusions

We believe that augmented group awareness tools enrich our repertoire of CSCL technologies both for practical use and for scientific inquiry. Whereas some considerations for the scientific investigation of these tools were addressed in the preceding section, it is evident that practical use of augmented group awareness tools faces additional hurdles. Issues of learner compliance and scalability across group sizes are the first that come to mind. Research into practical use of these group awareness tools might be conducted in mobile learning scenarios, thereby taking into account affordances and constraints of this particular technology.

In terms of the scientific analysis of tools we believe that they are open to investigations based on a range of epistemologies (Suthers, 2006). While many processes involved in collaborative learning can be made visible and quantifiable with these tools, thereby lending themselves to an experimentally-oriented epistemology of knowledge communication, it is of course possible to hermeneutically describe and analyze knowledge building processes that take place during group discussions, and examine the ways they unfold under the influence of ratings and/or visualizations. On a final note, it should be repeated that augmented group awareness tools as described in this study stand for a potentially new philosophy of learner guidance. While they are far from being as directive as other methods (e.g. scripted cooperation), they avoid the pitfall of leaving collaborative groups without any guidance. Being well-informed, but fully autonomous might be an interesting metaphor for collaborative learning that is well worth studying in entirely different contexts of CSCL.

References

Asch, S. E. (1956). Studies of independence and conformity: A minority of one against a unanimous majority. *Psychological Monographs, 70* (whole no. 416).

Bell, P. (1995). How far does light go?: Individual and collaborative sense-making of science-related evidence. *Annual Meeting of the American Educational Research Association, San Francisco* (poster presentation).

Brodbeck, F., Kerschreiter, R., Mojzisch, A., Frey, D. & Schulz-Hardt, S. (2002). The dissemination of critical, unshared information in decision-making groups: The effects of pre-discussion dissent. *The European Journal of Social Psychology, 32*, 35-56.

Carroll, J. M., Neale, D. C., Isenhour, P. L., Rosson, M. B., & McCrickard, D. S. (2003). Notification and awareness: Synchronizing task-oriented collaborative activity. *International Journal of Human-Computer Studies, 58 (5)*, 605-632.

Christiansen, N & Maglaughlin, K. (2003). Crossing from Physical Workspace to Virtual Workspace: be AWARE!, *Proceedings of HCI International Conference on Human-Computer Interaction*, Lawrence Erlbaum Associates, New Jersey 1128 – 1132.

Deutsch, M. & Gerard, H. B. (1955). A study of normative and informational influence upon individual judgement. *Journal of Abnormal and Social Psychology, 51*, 629-636.

Dillenbourg, P. (2002). Overscripting CSCL: The risks of blending collaborative learning with instructional design. In P. Kirschner (Ed.), *Three Worlds of CSCL: Can we support CSCL?* (pp. 61-91). Heerlen: Open Universiteit.

Doise, W. & Mugny, C. (1984). *The social development of the intellect*. Oxford: Pergamon.

Endsley, M. (1995). Towards a theory of situation awareness in dynamic systems. *Human Factors and Ergonomics Society, 37(1)*, 32-64.

Gross, T., Stary, C. & Totter, A. (2005). User-Centered Awareness in Computer-Supported Cooperative Work-Systems: Structured Embedding of Findings from Social Sciences. *International Journal of Human-Computer Interaction, 18*, 323-360.

Gutwin, C. & Greenberg, S. (2002). A descriptive framework of workspace awareness for real-time groupware. *Computer Supported Cooperative Work, 11*, 411-446.

Hastie, R., Penrod, S. D. & Pennington, N. (1983). *Inside the jury*. Cambridge: Harvard University Press.

Höök, K., Benyon, D. & Munro, A. (Eds.) (2002). *Designing Information Spaces: The Social Navigation Approach*. London: Springer.

Jermann, P., Soller, A. & Mühlenbrock, M. (2001). From mirroring to guiding: A review of the state of art technology for supporting collaborative learning. *Proceedings of Euro-CSCL 2001*, 324-331.

Johnson, D. W. & Johnson, R. T. (1992). *Creative Controversy: Intellectual Change in the Classroom*. Edina: Interaction Book.

Konstan, J. A. & Riedl, J. (2002) Collaborative Filtering: Supporting Social Navigation in Large, Crowded Infospaces. In K. Höök, D. Benyon & A. Munro (Eds.), *Designing Information Spaces: The Social Navigation Approach* (pp. 43-82). London: Springer.

McLeod, P., Baron, R. S., Marti, M. W., & Yoon, K. (1997). The eyes have it: Minority influence in face to face and computer mediated group discussion. *Journal of Applied Psychology, 82*, 706-718.

Moscovici, S. (1976). *Social Influence and Social Change*. London: Academic Press.

Nemeth, C. (1986). Differential contributions of majority and minority influence. *Psychological Review, 93*, 23-32.

Stasser, G. & Titus, W. (1985). Pooling of unshared information in group decision making: Biased information sampling during discussion. *Journal of Personality and Social Psychology, 48*, 1467-1478.

Stewart, D.D. & Stasser, G. (1998). The sampling of critical, unshared information in decision-making groups: The role of an informed minority. *European Journal of Social Psychology, 28*, 95-113.

Suthers, D. D. (2006). Technology affordances for intersubjective meaning making: A research agenda for CSCL. *International Journal of Computer-Supported Collaborative Learning, 1(3)*, 315-337.