A Collaborative Multi-source Intelligence Working Environment: A Systems Approach

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Abstract. This research applies a systems approach to aid the understanding of collaborative working during intelligence analysis using a dedicated (Wiki) environment. The extent to which social interaction, and problem solving was facilitated by the use of the wiki, was investigated using an intelligence problem derived from the Vast 2010 challenge. This challenge requires "intelligence analysts" to work with a number of different intelligence sources in order to predict a possible terrorist attack. The study compared three types of collaborative working, face-to-face without a wiki, face-to-face with a wiki, and use of a wiki without face-to-face contact. The findings revealed that in terms of task performance the use of the wiki without face-to-face contact performed best and the wiki group with face-to-face contact performed worst. Measures of interpersonal and psychological satisfaction were highest in the face-to-face group not using a wiki and least in the face-to-face group using a wiki. Overall it was concluded that the use of wikis in collaborative working is best for task completion whereas face-to-face collaborative working without a wiki is best for interpersonal and psychological satisfaction.

Keywords: Collaborative working, intelligence analysis, Wiki.

1 Introduction

Recent intelligence failures, and subsequent reports, have emphasised the need for better ways to organise, manage, and support intelligence analysis (Butler, 2004; 9/11 Commission Report, 2004; Posner, 2005; Murphy, 2006;). A common theme throughout these reports is the need for greater collaboration between the agencies and individuals involved. In the USA projects such as A Space and Intellipedia have been developed to promote and support such collaboration. However, the way in which collaborative work is organised can vary considerably and we need more research to inform decisions on the nature of complex collaborations. For example Convertino et al (2008) investigated the effects of group composition in computer

D. Harris (Ed.): EPCE/HCII 2013, Part I, LNAI 8019, pp. 281–289, 2013.

supported collaborative intelligence analysis and found that individuals working with like-minded individuals tended to show and retain greater bias in their analytical judgements than did individuals working in more heterogeneous groups. Neville (2009) has considered the diagnostic errors that can accrue from co-operative working during a friendly fire incident in Iraq. His study illustrated how processes of cooperation can be vulnerable and ultimately fail, particularly when multiple participants are physically distributed and interaction is mediated by communication technologies. In the context of military intelligence analysis Jones et al (1998) have described the use of 'CoRAVEN', an intelligent collaborative multimedia system to support intelligence analysts a forerunner to the more sophisticated Wikis that are now widely available.

The use of collaborative tools such as wikis has also been investigated in the context of intelligence analysis. In this context a wiki is defined as software that allows users to create and edit the content of a document usually via a web browser.Wheaton (2008) studied this extensively both in classroom and real world environments. The findings revealed that Wikis can help to facilitate collaboration to a high degree and that the final intelligence product is often much better than that produced by traditional methods (e.g. face-to-face collaboration).

1.1 A Systems Approach to Collaborative Working

The benefits of collaborative working within the intelligence community appear to be well established (Wheaton, 2008). What is less clear is exactly how collaborative working necessarily leads to a superior intelligence product. One way to examine this problem, and clarify the cognitive and psychosocial factors involved, is to use a systems approach.

Collaborative knowledge building, especially where Wikis or other collaborative software is used can be understood in terms of a system with three facets. The first to consider is the cognitive processes of the individuals involved in the collaborative working. The second aspect of this system is the psychosocial processes that influence group functioning and the third is the group organisation itself. These three aspects of this system will interact and it is this interaction that will lead to the desired collaborative learning. Using this systems approach it is possible to examine in detail how different factors interact to produce new emergent knowledge and this will lead to a greater understanding of collaborative working and its impact on intelligence analysis.

1.2 Accommodation and Assimilation

This systems approach is based on the work of Cress and Kimmerle (2008)who also attempted to describe the learning process itself in terms of the Piagetian concepts of assimilation and accommodation (Piaget, 1970). Although usually considered in the context of individual learning the concepts of assimilation and accommodation can be usefully applied in the understanding of collaborative learning. Working collaboratively involves more than simply sharing information. For example if I give you a recipe and you give me details of a good garage we have exchanged information but

no new knowledge has been produced. In collaborative working Cress and Kimmerle (2008) suggest four different types of learning:

- internal assimilation (quantitative individual learning)
- internal accommodation (qualitative individual learning)
- external assimilation (quantitative collaborative knowledge building)
- external accommodation (qualitative collaborative knowledge building).

Together these four types of learning are responsible for the new emergent knowledge that should be a feature of collaborative working.

Where individual knowledge differs from the Wiki (collaborative) knowledge this produces cognitive conflict which people are motivated to reduce, and which Piaget referred to as equilibration (Piaget 1977a). The need for equilibration can be satisfied by a process of internal or external assimilation and accommodation.

Assimilation and accommodation do not only occur internally within the individual, but also externally within the wiki itself. Majchrzak et al (2006) distinguishes between people who simply contribute to a wiki without reference to previous contributions, these are called 'adders'. This type of contribution is assimilated by the wiki which is extended but fundamentally remains the same, as no data reorganisation takes place. The other type of wiki contributor is the 'synthesizer'. These are people who not only add to the existing information, but also reorganise information in a new way by reference to what already exists.

The process of adding information to a Wiki is akin to assimilation and is very common whereas that of accommodation is less so. Accommodation within the Wiki will be shown through the integration of ideas that have already been contributed to produce new ideas. These will show up in the Wiki in terms of the reorganisation of pages or even the rewriting of whole sections.

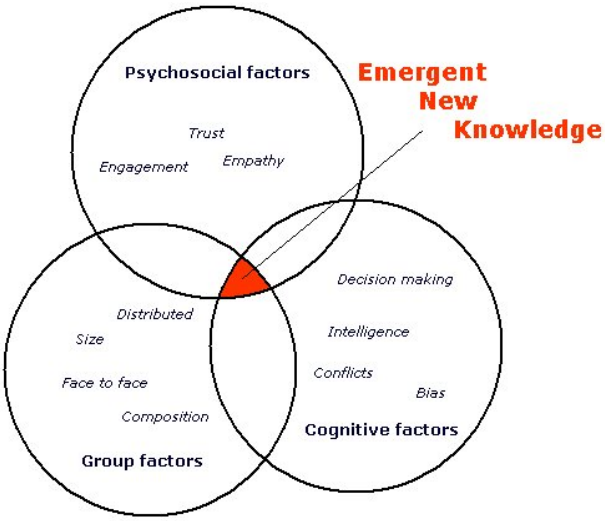

Fig. 1. The interaction of the three facets of the system leads to emergent knowledge

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2 Methodology

Design. The aim of this research was to use a systems approach to aid the understanding of collaborative working during intelligence analysis using 'WorkSpace' a dedicated wiki environment . A mixed methodology was used to examine how group functioning influences team sensemaking (Klein et al, 2010) during intelligence analysis. Specifically the study looked at how shared information is assimilated and accommodated by the group to create new knowledge during the analytic process.

WorkSpace has been developed based on the work of Clark (2009) and Heuer and Pherson (2010) and is designed to foster a collaborative environment as well as help analysts use a more structured approach in their work. Collaborative working is supported in WorkSpace via a link that uses IntelliWiki as a platform on which groups of analysts can work together on a given problem. The inputs, (i.e. edits from all collaborating analysts), are recorded by IntelliWiki thus facilitating later analysis when the task is complete.

The task used in this research was derived from the open source IEEE 2010 VAST Challenge, Mini Challenge 1 (http://hcil.cs.umd.edu/localphp/hcil/vast10/index.php) and involved participants analysing multi-source intelligence data, including email and message board intercepts, news reports, web site and blog postings, transcripts from telephone intercepts, and government intelligence reports.

The study compared three different groups working on the same task:

- Group 1: used 'Wiki' + face-to-face contact; referred to as Combo Group, (University of Salford).
- Group 2: used only 'Wiki', without face-to-face contact; referred to as Wiki Group, (University of Nottingham).
- Group 3: used only face-to-face interaction with no access to WorkSpace or any other software apart from a word processor; referred to as F2F Group, (University of Liverpool).

Resource limitations meant that for this initial study we could only test a small number of working groups. However this approach would produce a great deal of valuable quantitative and qualitative data, which would allow the first detailed analysis of the way groups generate collaborative knowledge in a quasi-real world task to be conducted.

It was hypothesised that there would be a relationship between the type of group and the output from the group in terms of both task completion, individual contribution and levels of satisfaction with the task. The following hypotheses were proposed:

- Group 1 (Combo) would perform at the highest level, there would be more evidence of emergent knowledge and this would be produced more quickly and thus contribute to more effective task completion.

- Group 2 (Wiki) would have similar levels of task completion as Combo but would have the lowest levels of interpersonal and psychological satisfaction.
- Group 3 (F2F) would be the worst performers in terms of task completion but would exhibit higher levels of interpersonal and psychological satisfaction than the other two groups.

Participants. Three groups of six 'analysts',(three male, three female), were used at each University location. As this study investigated fundamental issues of collaborative working, the 'analysts' were university students, rather than professional intelligence analysts. The rationale for this was that university students would all be equally 'naïve' in dealing with intelligence problems and therefore this would minimize group problems that might have occurred due to differences in levels of expertise or experience if professional analysts were used.

Materials. Participants were provided with access to a multi-source intelligence database from where they could download the materials for analysis. How and when they chose to access this database was for the group to determine between themselves.

Two questionnaires were developed. The first assessed how well the participants knew each other and their level of computer and Wiki literacy.

The second assessed levels of interpersonal and psychological satisfaction using a modified version of the Survey Instrument (for Virtual Teams), developed to assess relational links in virtual teams by Warkentin, Sayeed and Hightower (1997).

Procedure. The participants were recruited using the procedures determined by the individual University ethics committees. The three groups of participants were asked to attend a briefing session where details of the task, and their involvement were outlined. For Groups 1 (Combo) and 2 (wiki), they were introduced to 'WorkSpace' and the 'IntelliWiki' where they each were to record details of their analysis. The task was explained and they were informed that they had two weeks to complete the task. The rationale for the two week timescale was that this better reflected the way in which wiki construction occurs, (i.e. over a relatively prolonged period). Participants in the Combo and Wiki groups were informed that all work had to be completed online, working either synchronously or asynchronously, using the 'WorkSpace' facility provided. Participants in the Wiki group were also informed that they should not discuss the problem with other members of the group when they were not online. Furthermore, all the participants were told that they should not discuss the task, online or offline, with anyone who was not a member of their group. Group 3 (F2F) met face-to-face according to a timetable they drew up to meet the requirements of a ten hour involvement with the task. All discussions were minuted and recorded using a word processor.

All participants were asked to sign a consent form and also agreed that if they were found to have broken any of the interaction rules they would be required to withdraw from the study and forfeit their payment. This was done to stop participants using the Internet or any other information sources to assist with their analysis.

The Task. The three groups all completed the same task derived from the IEEE 2010 VAST Challenge, Mini Challenge 1 (http://hcil.cs.umd.edu/localphp/hcil/vast10/index.php). Working collaboratively with other members of their group, they used the resources provided to produce a summary of activities that had happened in each country, with respect to the illegal arms dealing. Based on a synthesis of the information from the different report types and sources they were also required to:

- state the situation in each country at the end of the period (i.e. at the end of the information they had been given) with respect to the terrorist act being planned.
- present a hypothesis about the next activities they expected to take place, with respect to the people, groups and countries.

For the Combo and Wiki groups the results of the analysis were presented in the form of a Wiki report submitted in the WorkSpace. The F2F group produced a word processed report in hard copy.

Analysis. The data to be collected was in the form of 'IntelliWiki' transcripts that were recorded in the 'WorkSpace' which included the individual edits of each group member as well as final reports. Data from F2F group was in the form of minutes from their meetings along with a transcript of the audio recordings of their discussion. The emerging individual and collaborative ideas were examined for evidence of accommodation and assimilation as the group progressed towards completion of the task. Using the concepts of adders and synthesisers suggested by Majchrzak et al (2006) the transcripts and minutes were subjected to textual analysis where the main aim was to distinguish between content that was simply added (assimilation) as opposed to content that was the result of integration and reorganisation (accommodation). The data was also examined for evidence of conflict or incongruity and the resultant equilibration. This would support the hypothesis that assimilation and accommodation had contributed to collaborative knowledge building. Because the data from the three locations was being assessed by different research assistants, inter-rater reliability was evaluated before detailed analysis.

3 Results

The results are presented in two parts. The first deals with the social and psychological dynamics of the collaborative working, examining how the participants worked together, group cohesiveness and how they felt about their contribution to the task. In the second part, performance on the task itself is examined looking for evidence of emergent knowledge resulting from the processes of assimilation and accommodation within the three different groups.

Social and Psychological Dynamics - Overall Summary. The groups displayed similar levels of computer and Wiki expertise and had similar relationships before the study began. In the post-test questionnaire for psychological satisfaction the F2F group exhibited significantly higher ratings than the other two groups on all three

dimensions as predicted. However there was no significant overall difference between the Wiki group and the Combo group on any of the overall dimensions. Furthermore the Wiki group showed a higher mean, and when looking at individual items this group rated significantly higher than the Combo group on some measures (the reverse was never the case). So our prediction that the Combo group would display higher levels of satisfaction was not confirmed, indeed the data suggests a trend in the opposite direction. However it should be noted that this trend may be due to intra-group conflict within this group as evidenced by the participant comments and therefore any conclusions should be treated as tentative.

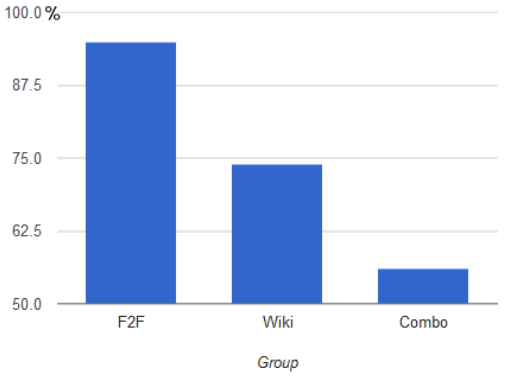

Fig. 2. Psychological Satisfaction Levels in the Three Groups

Analysis of the Task Data – Overall Summary. In the VAST Challenge it is acknowledged that there is no single solution to the task set. Judges will evaluate submitted solutions, make comments and judge what they believe to be the best, rather than, correct, solution. In evaluating the solutions offered by the three groups in this research a similar approach was used.

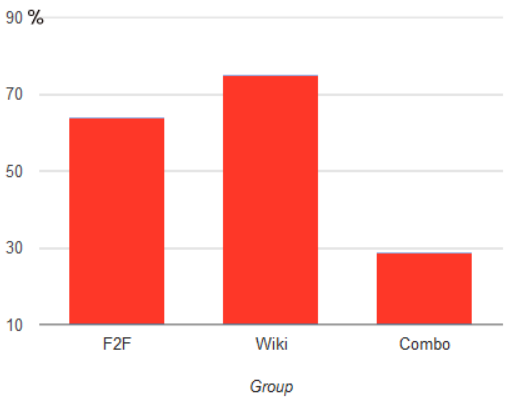

Fig. 3. Comparison of Task Evaluation in the Three Groups

All of the submitted reports were marked using the VAST 2010 sample answer as a basis. A mark was given for each of a possible 96 points about the various groups that were outlined in the VAST answers. The Wiki group scored the highest with 75%, the F2F group next with 64% and the Combo group scored the lowest with just 29%. Overall the Wiki group were better at preserving all of their findings while the F2F group provided a more coherent and structured report.

Analysis of the Wiki Data - Overall Summary. The Combo and Wiki groups who both made use of the Wiki in their collaborative analysis produced data that was highly consistent. The proportions of accommodation and assimilation were found to be very similar and this suggests that the methodology has managed, to some extent, to capture the process of emergent knowledge (see Figure 4).

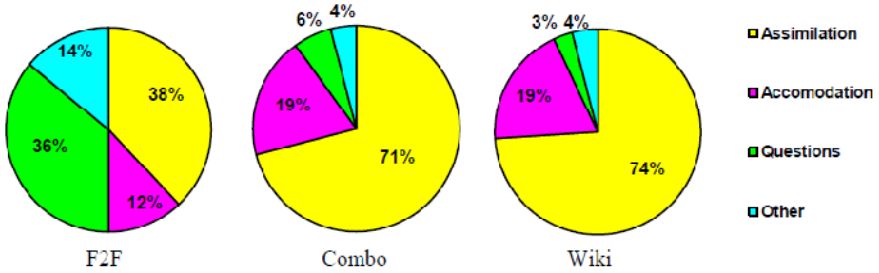

Fig. 4. Charts showing the proportion of each of the coded categories

Comparisons with the group not using a Wiki (i.e. F2F) are interesting in that again similar proportions of accommodation and assimilation are found but within a data set containing much social dross, i.e. the non-task elements that are a feature of face-to-face groups. From this perspective the Wikis are useful tools in that they appear to focus the group on the task and away from the 'social niceties'. This was also apparent as the Wiki group produced the most effective solution to the problem set.

4 Conclusions

The use of Wikis to aid collaborative intelligence analysis, to some extent, has been supported by the findings of this research. Both in terms of effective task analysis, and group satisfaction, people working as part of a group, at a distance, and with no face-to-face contact, communicating via a Wiki, feel they are making a worthwhile contribution to the collaborative effort, are trusted by other group members, and, perhaps most importantly, are most effective at completing the task.

Collaborative intelligence analysis is undoubtedly a highly complex cognitive/social undertaking and this research has demonstrated that Wikis can help in this respect. However, unless the group dynamics of the situation are factored into the collaborative working, then the potential benefits of this approach will be severely curtailed.

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