The CHI 2008 workshop on sensemaking was the second of its kind. Another workshop on sensemaking was held at CHI 2005. (A position paper by this author and a co-worker was also accepted for that workshop). (See http://dmrussell.googlepages.com/sensemakingworkshoppapers for the actual papers and Appendix A for the titles and corresponding author of these papers). We spent the morning and the first part of the afternoon hearing brief presentations. The papers were made available to the group electronically and were also sent in hard copy to the workshop participants so we had the opportunity to read these ahead of time. In the afternoon discussions were opened up and the group came up with a list of questions/issues that we need to address. It was agreed that a workshop should be held again next year at CHI.

Summary of papers and presentations
A full list of papers submitted to the sensemaking workshop is available in Appendix A. The papers submitted fell into several categories:

- Models of sensemaking (5 papers)
- Tools to facilitate sensemaking (3 papers)
- Studies of sensemaking (6 papers)
- Collaborative sensemaking (4 papers)
- Metrics and evaluation of sensemaking (2 papers)
- Other (3 papers)

There is, of course, overlap. Some of the collaborative sensemaking papers may have tools described in them, and some of the papers on tools may present evaluation methods.

The sections that follow describe each of the categories in detail. A summary at the end of each category is the author’s viewpoint and does not necessarily reflect the opinions of the group. The final section is a list of issues/questions that participants felt need to be addressed in future sensemaking research.

Models of Sensemaking (5 papers)
Many of the papers in the workshop referred to work done by Russell, Stefik, Pirolli, and Card in InterChi ’93, The Cost Structure of Sensemaking. This paper looks at sensemaking costs as the sum of the costs associated with finding a representation schema to support operators in the target task; instantiating the schemas; finding the documents and selecting the information to fill in the schemas; and performing the target task. Sensemaking is a set of subtasks and tradeoffs can be made in one subtask to produce gains in another. In this view of sensemaking, information retrieval is viewed as part of the larger task. Several important aspects of this research are the learning loop, the anytime algorithm, and the notion that representation is instrumental in sensemaking. The learning loop has three processes – research for representations to capture salient features of the data; instantiate representations using information of interest, and shift representations to accommodate relevant data by expanding the schemas. The anytime algorithm provides the best solution possible in the allocated time. This is a tradeoff – if more time is available, then better solutions can be found.

Models of sensemaking at the workshop included the data-frame model of sensemaking by Klein et al., Devin’s “sense-making methodology,” and Pirolli’s model of social information foraging and sensemaking.

The data-frame model of sensemaking provides a description of how people generate an initial account to explain events and understand the current situation with new information flowing in. Situation awareness is a model of the current situation held in working memory. However, the process of building up situation awareness is explained by the data-frame model. The frame is the explanatory structure into which current data go. The frame defines and explains relationships, and guides the search for new data.
Dervin’s “Sense-making methodology” embodies six assumptions:
1. Effective communication requires a focus on head, heart, hand, habit, hegemony, and habitus. Research is itself a communication practice.
3. The sense-making methodology focuses on process and the ways people communicate. Verbs should be used to describe these activities.
4. The sense-making methodology is informed by numerous research traditions and hence may be able to bridge research traditions.
5. Power is assumed to be a force that constrains and/or facilitates sense-making.
6. There are multiple ways in which people engage in making sense and research should explore these.

The sense-making moment is depicted in the diagram below:

The Microstructure of Sensemaking by Takayama and Card was an elaboration on Sensemaking processes in intelligence analysis and possible leverage points as identified through cognitive task analysis by Pirolli and Card, 2005. In the earlier paper, they used cognitive task analysis to formulate the model of sensemaking below.
In this research they used time stamped logs and observational data to break down the sensemaking activities of a senior and a junior analyst. They classified activities as foraging, sensemaking, planning, and helping. Using these classifications they found four examples of patterns:

- **Exhaustive foraging**
  
- **Strategic foraging:**

- **Evidence marshalling**
  
- **Maintaining situation awareness.**

Exhaustive foraging patterns show access – search – skim [repeat until find a lead to pursue] – gather – annotate [repeat].

Strategic foraging – in this pattern the analyst goes to some familiar information (documents/databases already read and stored by the analyst) search (person documents) – gather – [repeat until exhausted] search (other sources).

Evidence marshalling – in this pattern analysts are starting to compose relevant information Compose-search-gather [repeat].

Maintaining situation awareness – this pattern acknowledges that data is dynamic. Situations change over time. Hence analysts need to monitor information to ensure that there is nothing new/surprising that needs to be incorporated into their work. The pattern is access-skim – [repeat].

Pirolli presented a model of social foraging and sensemaking. The key predictions of this model are:

- If individuals collaborate in foraging they are able to explore more of the information space than they could alone.
- If individuals cooperate in sensemaking they are more likely to make important discoveries.
- If the costs of cooperating are reduced the effective size of the cooperating group will increase.
Diverse groups are able to mitigate confirmation biases more effectively than homogenous groups

The model of sensemaking of Weick, 1995 looks at the social dynamics of organizational processes. Weick maintains that these are based on some mental structures and are used to create situational understanding for members of an organization. This was not presented at the workshop but the paper by Takayama and Card make reference to this notion of sensemaking.

Summary: The Klein, Russell et al, and Pirolli and Card models all acknowledge that representation of information is an important factor in sensemaking. The Klein model uses the frame as the basic representation, but this can be expanded on and questioned. The Russell et al. and Pirolli and Card models use several representations (shoebox, evidence file, and schema) which represent successive refinements of the information. Weick also talks about mental structures which get filled in with current data. The Dervin model does not explicitly discuss representations but shows the comparison of the situation and the outcome and notes that the bridge between those two is the sensemaking moment.

Tools to facilitate sensemaking (3 papers)
Russell, Jeffries, and Irani’s paper “Sensemaking for the rest of us” looked at the Google notebook, which is a plug-in to the browser and can be used to hold text, images, and links from web pages as well as user text. The authors obtained permission to look at 163 notebooks. They analyzed the notebooks to see how they were used.

Findings:
- Although Google notebook allows the creation of sections, less than half of the notebooks used this feature.
- Less than 5% of these notebooks had sections moved from one place to another.

In a follow-on study of usage in depth, we found that the notebook was used more to collect information than as a sensemaking activity. The lesson learned is that unless there is a clear model of the task to be done, the less structure imposed on users, the better.

In another study, the authors looked at spreadsheet use (Google Spreadsheet) and found that the majority of the spreadsheets were used for non-numeric purposes and many of them had significant structural changes over their history. Clearly there were representational changes going on and sensemaking. Lessons learned: Speed matters in changing representations. Searching for information in the representation has to be fast and easy. Navigating between elements (notebooks or worksheets) has to be easy.

Overall, representations need to be well-understood, fast and simple to use for people to use them in sensemaking.

Stasko describes the Jigsaw system and looks at the sensemaking activities that Jigsaw facilitates. Jigsaw has a number of components. Analysts can view documents to read; they can view entities from the documents in list, graph and scatter plot visualizations. They can use a calendar for temporal data. All views are linked – so an interaction with one visualization makes corresponding changes in all other visualizations.

Jigsaw supports information foraging activities by helping people find small collections of documents that may be relevant. Jigsaw supports evidence marshalling by providing a shoebox which helps analysts collect bits of information and organize it. The shoebox offers analysts a number of different ways to organize and combine information, including the ability to link to a specific view. In addition, Jigsaw allows analysts to disconnect a particular view. This allows the analyst to do more exploration – what ifing – while saving a particularly useful state.

The Backstory system is a search tool for software developers at Microsoft. Initial work was done with a software developer responsible for root cause analysis. The schematic of his workflow was basically an information foraging loop, including identifying relevant items and annotating followed by formulating
hypotheses and evidence marshalling; concluding with a report being generated. The tool has been available for several months and soon there will be a push for folks to use it, followed by some interviews and surveys of use.

Summary: The tool builders all seem to understand the notion of representations and the idea that tools have to support not only the different aspects of sensemaking but the seamless transition between these sensemaking activities. Heavyweight tools take too much of the user’s cognitive processes that must be used for sensemaking.

Studies of Sensemaking (6 papers)

Information Seeking: Sensemaking and Interactions – this work looked at a number of experienced information processors, who were asked to find information and prepare a 15 minute slide presentation (in outline form only). The researchers observed a number of interactions:

- seek – looking for sources
- eval (s) – evaluation for selection
- eval (u) evaluate for use
- compile – use
- plan – gather requirements, set or revise goals

They also found patterns of these interactions.

Investigations within investigations: a recursive framework for scalable sensemaking support. This paper reported a case study of a large fraud investigation done by 30 lawyers over 3 months of time looking at 8.5 million documents. The lawyers had to both decompose the task and coordinate the investigation. Investigations found information that provided a more focused inquiry that was independent in that it posed new questions but was in fact, only a sub problem, and the results had to be propagated up to the higher level issues.

People sensemaking with social networking sites – This paper reports on a study of an IBM internal social networking site called Beehive. Researchers found that users spend more time looking at their friends (in depth searches) but look at more non-friends (breadth searches).

An empirical study of firefighting sensemaking to inform the design of ubicomp technology – The researchers ran several simulated reconnaissance missions in a training facility. The firefighters walked through a building trying to locate a water bottle. Collaborative sensemaking occurred in handover and debriefing tasks. Firefighters work for 30 minutes then take a break – they have to communicate handover information to the team relieving them. They talked and drew on an ad-hoc map. They also communicate uncertainty. Depending on their roles, firefighters perceive the information differently.

How we make sense of instructions – this work looked at how people make sense of origami instructions. This looked at the form of the information, the timing of the information, the pace of the information and where the information is presented. The paper also talks about registration – aligning a representation with the physical world (think about turning a map as you follow the directions).

Collaborative Sensemaking: This was a field study in an emergency room in a teaching hospital. It uses an electronic medical record and a computerized provider order entry system. They looked at four types of collaborative tasks (McGrath) – planning, intellectual, decision-making, and performance. Situation and activity awareness are important in collaborative sensemaking. Essentially it was necessary for emergency room workers to ask others what they were doing (activity awareness) and how patients were doing (situation awareness) not for a current task but to maintain a larger picture necessary for making decisions about the “next” emergency.

Narrative, Sensemaking, and Improvisation in Participatory Hypermedia Construction. Two case studies – the first one looked at teams of people devising a knowledge mapping exercise. The second case study was a remote science team using a virtual meeting to analyze data and make recommendations for the next day. The researchers found that narrative was used to add context to sensemaking behaviors – in particular when
something goes wrong with the collaborating sensemaking, some improvisation takes place. Capturing the narrative would help to put this in context.

Summary: In the diverse domains investigated here, we see that representations play a large part in sensemaking activities. We also see some interesting aspects when sensemaking is interrupted – and some improvisation needs to be done. Patterns are found in everyday sensemaking that are inline with the models of sensemaking formed by studying intelligence analysts. There was an interesting recursive sensemaking when 30 lawyers were working on focused but not wholly independent sensemaking tasks. The study of making sense of instructions also points out that the timing of information is important in sensemaking. A document may seem irrelevant at one point but become relevant later.

*Collaborative sensemaking (4 papers)*

Group Sensemaking summarized two studies of group sensemaking looking at social structures, artifacts and associated processes. They identified boundary negotiating artifacts. Practices for sensemaking in collaborative work are not always agreed upon and well understood. There are breaks between groups and partial understanding – and to some extent these breaks extend to the understanding and use of representational and coordinative artifacts. For example, one group used some external representations to manage a balance between innovation and potential disruptions caused by innovations (a Change request form that was reviewed by individuals in the two groups).

Sensemaking: Enhancing the Value of Collaborative Web Search Tools looked at three prototype systems developed to support collaborative search. Prototypes differed as to whether they supported remote or co-located search, asynchronous or synchronous search. While the tools currently have shown useful features, subjects are interested in richer sensemaking search activities such as being able to edit summaries to the group. In addition, the designers are interested in exploring ways for groups to be able to share the process as well as the products.

Building Shared Understanding in Collaborative Sensemaking investigates shared representations and how this leads to shared understanding. Explicit representations (visualizations) can be used in collaborative sensemaking in interdisciplinary groups to reveal differences in content – topics, connections and differences, keywords and domain specific words. If collaborators create representations individually, what are the actions necessary for integrating these representations?

Facilitating Collaborative Sensemaking in Distributed Project Teams Using Computer Supported Cooperative Work (CSCW) tools looks at issues that distributed teams face such as the lack of social awareness of what others are doing, the awareness of other work products and the awareness of contrasting goals and constraints of team members. They sketch a study that will be carried out on two distributed teams varying the visualization tools and communication tools. The researchers will measure collaborative sensemaking (change in agreement over time and integration of information sources) and quality of decisions and outcomes as assessed by experts.

Summary: Collaborative sensemaking has additional issues in that team members can be interdisciplinary and hence often have a different understanding based on their particular field of study. Looking at the process of group sensemaking in addition to the product of the sensemaking can be helpful to a group. Explicit representations of group understanding can also be helpful to the group.

*Metrics and evaluation of sensemaking (2 papers)*

Metrics for Sensemaking in Enterprise Tag management suggests several metrics for describing social – tagging of resources. They studied a number of IBM internal sites and looked at a NormInfo and three measures of social–agreement (modal, plural and unique) to measure the tags. NormInfo is entropy scaled between a theoretical upper and lower bound for a given number of tags. A modal tag is the tag that occurs most frequently; plural is a tag that occurs more than once; and unique is a tag that occurs only once in a collection.

Progress and Challenges in Evaluating Tools for Sensemaking discussed the VAST 2006 and the VAST 2007 contest and the associated metrics used. While these metrics look at the overall outcome of
sensemaking (a high quality debrief) and the accuracy of the debrief (ground truth is known in the dataset), more metrics are needed to assess the value of the tools to the different aspects of sensemaking.

Summary: Collaborative metrics of sensemaking should certainly include some measure of the agreement over time. For individual sensemaking activities we suggest developing a number of hypotheses about functionality that could enhance each aspect of sensemaking and testing these in laboratory studies and in observations in the real world to determine if the functionality is used and in what aspect of sensemaking.

Other (3 papers)

Does ontology help make sense of a complex world or does it create a biased interpretation? This paper discusses two text-mining techniques applied to accident report analysis. The problem was to find signatures of interesting accident reports. Association rule techniques did not work as they generated too many rules, and the most interesting reports were not in the top findings. They then used an ontology based mining technique to guide the search. They measured the relevance of an item according to the domain ontology and to the semantic distance and relevance assessment (user interested in concepts).

Representational Change in Sensemaking looks at models of representational change and their strengths and weaknesses. One model captures small incremental representational changes due to local refinements. The second model captures the goodness of fit and the larger changes in radical reorganization.

Summary: Representations and associated changes can be viewed both as visualizations and as mathematical descriptions. It would be interesting to look at the visualizations used in a number of tasks, including the outcome (insights) gained and to characterize these in the mathematical descriptions to determine if the smaller changes or the more radical changes lead to greater insights and in what time frame.

Questions and Issues that arose from discussion session

1. Situation awareness versus problem solving versus sensemaking – need to clarify the distinction between these
2. What are relevant characteristics (dimensions) of sensemaking? How can we make the connections between the relevant dimensions?
3. What is the role of creativity in sensemaking? Is there a role? Are more creative people better sensemakers?
4. Can we distinguish between novel and routine sensemaking?
5. Can registration be used to “find your way” into the semantic domain? How can you figure out what the domain is?
6. How do tasks and goals get represented into the process of sensemaking?
7. What are failure modes of sensemaking?
8. Does the design of sensemaking tools for individuals differ from those for groups?
9. Are there opportunities for reducing the cost of collaborative sensemaking? What are they?
10. What is the relationship between sensemaking and cocology of other structuring processes?
11. How do you know when sensemaking is done? How do you know when you are right? How do you estimate your confidence?
12. How generalizable are the lessons learned about sensemaking? How task-specific?
13. What is the cost of failure of sensemaking?
14. How do we communicate the sense that is made to the people who consume it?
## Appendix A

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<th>Author</th>
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