Multimodal, Multiuser Immersive Brainstorming and Scenario Planning for Intelligence Analysis

Shannon Briggs
Communications and Rhetoric

Rensselaer Polytechnic Institute
Troy, NY
briggs3@rpi.edu

Michael Perrone
IBM Thomas J. Watson Research Laboratory
IBM
Yorktown Heights, NY
mpp@us.ibm.com

Matthew Peveler
Computer Science
Rensselaer Polytechnic Institute
Troy, NY
pevelm@rpi.edu

Jaimie Drozdal
Cognitive Immersive Systems Lab
Rensselaer Polytechnic Institute
Troy, NY
drozdj3@rpi.edu

Lilit Balagyozyan
Mechanical Engineering
Rensselaer Polytechnic Institute
line 4: City, Country
balagl@rpi.edu

Hui Su
IBM Thomas J. Watson Research Laboratory
Yorktown Heights, NY
huisuibmres@us.ibm.com

***Abstract*—This paper discusses two pieces of software designed for intelligence analysis, the brainstorming tool and the Scenario Planning Advisor. These tools were developed in the Cognitive Immersive Systems Lab (CISL) in conjunction with IBM. We discuss the immersive environment the tools are situated in, and the proposed benefit for intelligence analysis.**

Keywords—brainstorming, risk assessment, scenario planning, cognitive immersive software, multimodal interaction

I. INTRODUCTION

The success of digital technologies for intelligence analysts depends on their ability to effectively support analysts' cognitive workloads. To that end, this paper introduces two sensemaking tools that have been developed according to Pirolli and Card's [1] sensemaking theory. The tools have been developed as a collaboration between the RPI Cognitive and Immersive Systems Lab (CISL) and IBM, and run in CISL. They facilitate cognitive workloads by enabling users to easily discuss and collaborate. The first, a digital brainstorming tool for information foraging, allows users to record pieces of salient and relevant interest on digital sticky notes from documents. The second, IBM's Scenario Planning Advisor (SPA) [2], is a foresight tool, which allows users to explore news stories, risk drivers, and signposts of change in dynamic complex environment. According to Pirolli and Card, the intelligence analysis sensemaking is completed in two major loops: the information foraging loop and the sensemaking loop [1]. The tools we have enabled cover both loops, with the digital brainstorming tool addressing the information foraging loop and the SPA tool addressing the sensemaking loop.

II. PRIOR WORK

Prior work in developing intelligence analysis tools has been well documented in a variety of fields. Example of such work includes Geotime [3], Sandbox and nSpace [4], Polestar [5], EWall [6], and Jigsaw [7]. While previous digital tools have focused on a desktop environment, our digital tools use multimodal technology in order to be more immersive, and the underlying cognitive framework allows users to engage in cognitive techniques already in use in the intelligence analysis domain. We have designed this environment to allow users to refine their ideas, search for information, and develop hypotheses and scenarios, and overall reduce the cognitive load during the sensemaking process.

The structured analytic technique of brainstorming has been reported by many authors who have developed educational materials for intelligence analysis, such as Beebe and Pherson [8]. Structured brainstorming is a way for analysts to critically examine materials in a formalized fashion, and discuss them in a group in order to gain the benefit of a diversity of opinions. Brainstorming as a cognitive task can be situated in Pirolli and Card's information foraging phase, as analysts are discovering new information, and sorting and filtering information as necessary [1]. The digital brainstorming tool developed by CISL is a translation of the analog exercise already in use by the intelligence analysis domain.

The SPA tool allows analysts to develop and discuss potential future scenarios and hypotheses [2], which are cognitive techniques already in use in the intelligence analysis domain. SPA allows analysts to draw knowledge from their schema and propose situations that lead to emerging risks, and develop courses of action. The sensemaking loop as laid out by Pirolli and Card describes the integration of information from the foraging phase into the sensemaking phase, where institutional teaching and personal knowledge developed by analysts are combined. We have been developing SPA to support the cognitive process of analysts developing scenarios.

Both tools in the CISL labs have been strongly informed by human-centric computing design principles. CISL is interested in human-in-the-loop software, and the design of both tools has been carefully considered to understand the user's

needs and actions throughout a possible interaction with the system. We have developed the tools through participatory design [9] and scenario-based design [10], as well as integrating education materials from textbooks and open source documents from the domain to shape the behavior of the tools at every step.

III. Literature Review

A. Sensemaking

Pirolli and Card's sensemaking theory has informed the design of the digital brainstorming tool, and informed the interaction design and the interface design of the SPA as it is enabled in CISL. Pirolli and Card proposed a notational sensemaking model describing the cognitive processes that analysts undergo when completing tasks in intelligence analysis [1]. The authors proposed analysts complete two major cognitive loops, the information foraging loop, where analysts find, filter and sort, organize, and prioritize information that they believe relevant to the problem they are dealing with, and the sensemaking loop, where analysts take the information they have found and begin to refine it into insights, schema, hypotheses, and eventually reports that are shared and disseminated as necessary. The model also describes sixteen distinct steps in the sensemaking process, connecting the information foraging loop to the sensemaking loop, as can be seen in Figure 1.

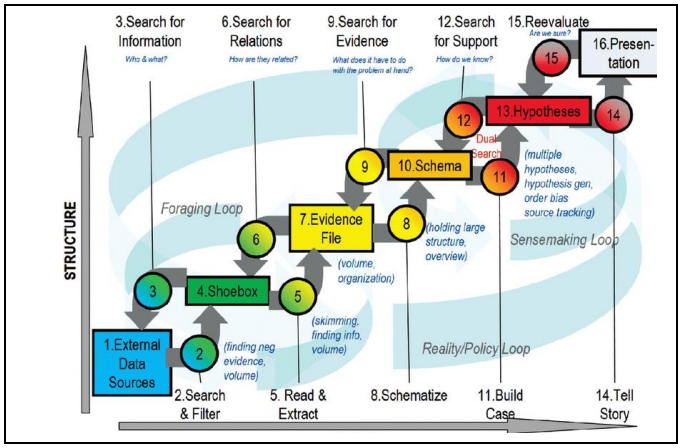

Fig. 1. Pirolli and Card's sensemaking model.

Pirolli and Card's model helps explain the cognitive needs that analysts encounter during the intelligence analysis process, and therefore what kind of software could support their tasks. We have discovered that structured analytic techniques that analysts use in their domain are analog cognitive processes to assist them in completing the sensemaking process. By aligning these structured analytic techniques with Pirolli and Card's model, we have discovered that we can assist analyst's sensemaking process by providing digital tools that are based on the structured analytic tools they are already familiar with. The software we present in this paper is meant to link the information foraging loop with the sensemaking loops; the brainstorming tool can be seen to fulfil part of the information foraging loop, largely focusing on steps 2, 3, and 4 (see Fig 1). The Scenario Planning Advisor can be considered to fill the schema step in the analysis process, allowing analysts to consult the training and experience they have in the domain and compare and integrate the information they have brought through the information foraging phase.

B. Structured analytic techniques

Structured analytic techniques are cognitive tools used by intelligence analysts, as well as other related domains, to help organize and formalize insights, decisions, and help analysts integrate this information through the sensemaking process. Structured analytic techniques have been developed in the intelligence analysis fields to address what the CIA Tradecraft Primer describes are the, "perennial problems of intelligence: the complexity of international developments, incomplete and ambiguous information, and the inherent limitations of the human mind." [11]

The brainstorming tool is an established structured analytic technique used by the intelligence analysis domain, as well as related domains. This technique is described by Beebe and Pherson as a 12-step group collaborative exercise [8], including:

1. Gather a group of analysts with domain knowledge to the specific problem.
2. Pass out sticky notes and pens to the team, and inform them there is no talking for this portion of the exercise.
3. Present the team with a question about the case or problem they are currently working with.
4. Ask the group to write down responses to this question on the provided sticky notes.
5. Place all sticky notes randomly on the wall as they are called out.
6. Usually after an initial wave of ideas, there is generally a pause as analysts consider the issue, and reinforce that talking is not allowed during this phase.
7. Complete two or three phases of the writing and long pauses.
8. Ask participants to go up and rearrange sticky notes on the wall into relevant categories.
9. When all sticky notes are rearranged, ask group to assign topic labels or category names to the groups that have emerged.
10. Look for outliers in the sticky notes, which are notes that do not fit into any categories. Sometimes these notes have ideas worth considering.
11. Consider what the group has created, and list what major forces they have discovered.
12. Present the results, and the key themes that the group has listed, and consider if they are worth further investigation.

The structured brainstorming technique has been used to inform the functions of the digital brainstorming tool as it is enabled in

978-1-7281-5092-5/19/$31.00 ©2019 IEEE

the cognitive immersive room. In conducting user studies of the brainstorming tool, we have found that it is important to the integrity of the brainstorming process to enable the convergent and the divergent thinking phases as they are described by Beebe and Pherson. Users are able to identify the key pieces of evidence the group finds most relevant, as well as take these findings through further steps in the sensemaking process.

IV. Cognitive Immersive Tools

A. Digital brainstorming tool

The development of the digital sticky notes tool has been informed by the traditional analog structured analytic brainstorming technique, which is discussed by Beebe and Pherson [8]. The digital sticky notes tool was developed to allow multiple users to simultaneously discover, filter, and sort information, and provide an introductory step in the foraging process described by Pirolli and Card [1]. The digital sticky notes tool allows users to engage in structured brainstorming, extract meaningful information from documents, and come to consensus about what information is most important. The tool is comprised of a global view (see Figure 2) and a personal view (see Figure3); the global view is displayed via five projectors onto a 360 degree screen. The personal view is a separate workspace accessible via web browser, and allows users to create and share notes to the global view from a personal device such as a tablet or a laptop. Currently, Kinect® gesture technology [12] and voice technology from IBM's Watson Assistant® are enabled to allow users to interact with the system. Users are able to create, edit, and delete notes and categories via voice and gesture commands. Users are able to point, grab, and drop notes around the screen, as recognized by body frame algorithms with the Kinect. Users are also able to issue verbal commands to the system such as, "Watson, delete that note". These multimodal technologies are enabled in the environment to provide a more immersive and intuitive experience for users. Currently, the storylines view that is accessible via SPA is enabled in the brainstorming tool as well, allowing users to browse through recent news stories, or refer to their own documents. When users are done with a brainstorming session, they are able to save the session and export the note contents and category topic labels into the SPA tool in a summarized format. This allows users to refer to the material and insight gained from the brainstorming session, and apply it to the scenario generation process.

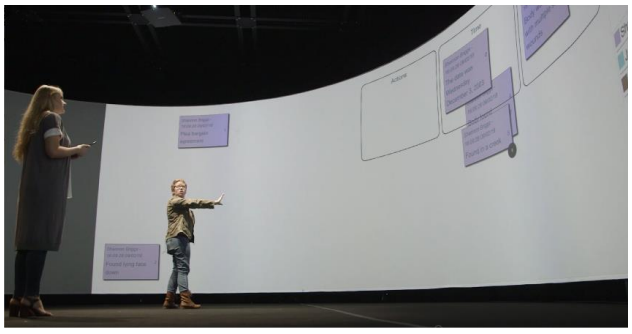

Fig. 2. Global view of the brainstorming tool in the cognitive immersive room.

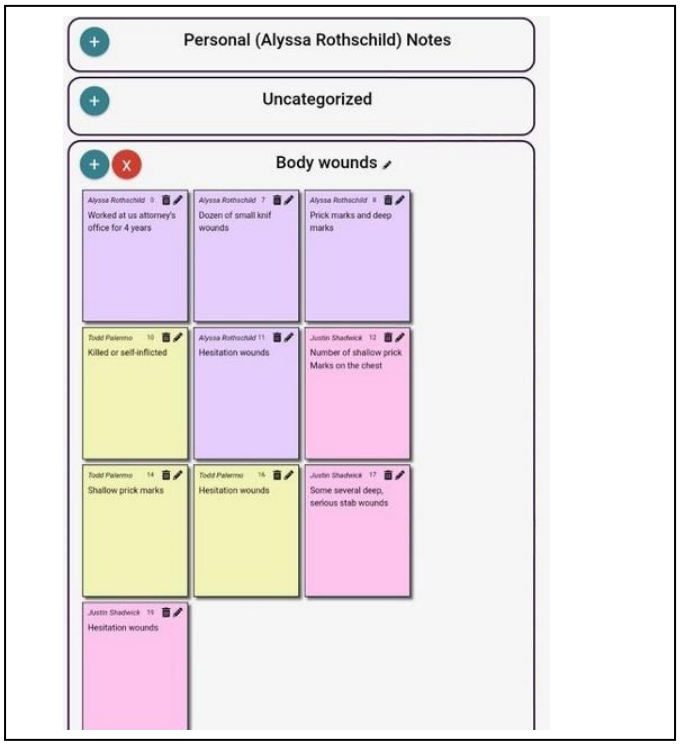

Fig. 3. Personal view of the digital brainstorming tool.

B. Scenario Planning Advisor

SPA is a tool developed by IBM and modified in conjunction with the CISL labs for development in an intelligence analysis use case [2]. The SPA tool was initially developed for use for economic and business analysts, and was designed to offer foresight of, and insight into, emerging business risks. The instance of the SPA tool developed between CISL and IBM has been modified to assist the sensemaking process in intelligence analysis, allowing users to search for new information and consult their own cognitive schema. The SPA tool includes cause-effect relationship models that are developed from insights from domain experts knowledge, and is captured in mind maps. These mind maps allow users to explore and select risk drivers to generate future scenarios. Users are able to browse through current news stories using the storylines view, and identify risk drivers of interest. Users are also able to refer to the summary of their brainstorming session to compare to recent news stories, as well as driver contents associated with the storylines. SPA generates emerging scenarios from these risk drivers, and gives recommendations of probable and possible risks and impacts. Users are also able to see these scenarios represented as graphs. SPA is currently enabled in CISL on the 360 degree screen, and gesture and voice technology is enabled to allow users a more immersive experience. Users can select and scroll through news stories and scenarios with the Kinect® gesture technology [12], and can give fine-tuned verbal commands to the system to help users glean deeper insights from the SPA. An example of the functionality of the SPA tool use case for Afghanistan is shown in Figure 4.

978-1-7281-5092-5/19/$31.00 ©2019 IEEE

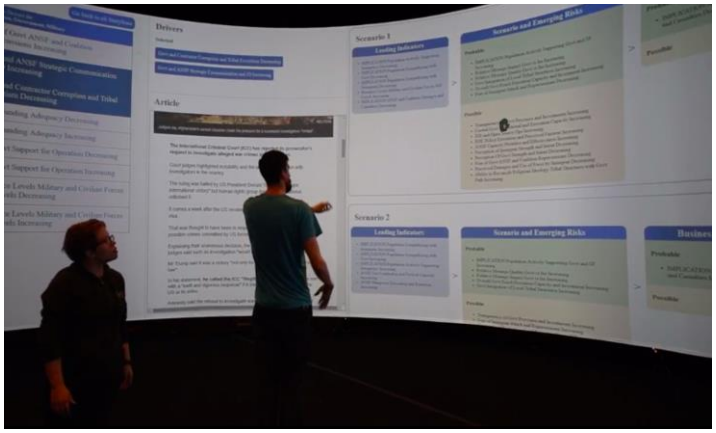

Fig. 4. The Scenario Planning Advisor in the cognitive immersive room.

V. Future Work

Future work for these tools will be to include natural language processing to reduce cognitive load for intended users. We are currently developing natural language causal relationship algorithms that can identify drivers in text segments. We are also developing algorithms that will be able to extract content from the brainstorming sticky note tool into the SPA tool, so that the SPA tool will have more human in the loop input. The tools will be enabled with more functionality to improve the level of control users have over the information they are interacting with and creating. We will be consulting former intelligence analysts from a local university for insight into features that will make the tools more useful and usable. User studies for the brainstorming tool are currently underway, and are planned for the SPA tool for the summer and fall of 2019.

References

[1] P. Pirolli and S. Card, "Sensemaking processes of intelligence analysts and possible leverage points as identified through cognitive task analysis," in *Proceedings of the 2005 International Conference on Intelligence Analysis, McLean, Virginia*, 2005, vol. 6.

[2] S. Sohrabi, M. Katz, O. Hassanzadeh, O. Udrea, and M. D. Feblowitz, "IBM Scenario Planning Advisor: Plan Recognition as AI Planning in Practice," p. 3.

[3] R. Eccles, T. Kapler, R. Harper, and W. Wright, "Stories in GeoTime," *Information Visualization; Thousand Oaks*, vol. 7, no. 1, pp. 3–17, Spring 2008.

[4] W. Wright, D. Schroh, P. Proulx, A. Skaburskis, and B. Cort, "The Sandbox for Analysis: Concepts and Methods," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, New York, NY, USA, 2006, pp. 801–810.

[5] N. J. Pioch and J. O. Everett, "POLESTAR: collaborative knowledge management and sensemaking tools for intelligence analysts," in *Proceedings of the 15th ACM international conference on Information and knowledge management*, 2006, pp. 513–521.

[6] P. E. Keel, "EWall: A Visual Analytics Environment for Collaborative Sense-making," *Information Visualization*, vol. 6, no. 1, pp. 48–63, Mar. 2007.

[7] C. Görg, Z. Liu, N. Parekh, K. Singhal, and J. Stasko, "Jigsaw meets Blue Iguanodon - The VAST 2007 Contest," in *In IEEE Symposium on Visual Analytics Science and Technology*, 2007.

[8] S. M. Beebe and R. H. Pherson, *Cases in Intelligence Analysis: Structured Analytic Techniques in Action*. CQ Press, 2014.

[9] D. Schuler and A. Namioka, Eds., *Participatory Design: Principles and Practices*. Hillsdale, NJ, USA: L. Erlbaum Associates Inc., 1993.

[10] M. B. Rosson and J. M. Carroll, *Human Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, Third Edition*. CRC Press, 2012.

[11] A. T. Primer, "Structured analytic techniques for improving intelligence analysis," *CIA Center for the study of intelligence*, 2009.

[12] R. Zhao, K. Wang, R. Divekar, R. Rouhani, H. Su, and Q. Ji, "An Immersive System with Multi-Modal Human-Computer Interaction," in *2018 13th IEEE International Conference on Automatic Face & Gesture Recognition (FG 2018)*, Xi'an, 2018, pp. 517–524.

978-1-7281-5092-5/19/$31.00 ©2019 IEEE