Tracing the Microstructure of Sensemaking

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ABSTRACT
Existing models of sensemaking describe high-level processes and abstract trends. We present low-level, empirically driven analyses of actual sensemaking behavior in both junior and senior intelligence analysts, offering insights from such low-level analyses and comparisons.

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Sensemaking, foraging, intelligence analysis

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Many human activities involve the collection of information and its reduction to support a specific action. Examples are writing a newspaper article analyzing foreign policy or shopping for a laptop. Typically such activities involve information gathering, re-representation of the information, development of insight from through marshalling or manipulating the information, and the execution of action based on the insight, such as creation of a report or direct action. We call this activity *sensemaking*. The purpose of this study is to learn more about its structure through empirical observation of intelligence analysts engaged in tasks involving science and technology warning. This paper gives a preliminary report on the study in progress.

Sensemaking is part of the more general activity of using information adaptively in the world, at which humans comparatively excel. It is not surprising, therefore, that the general phenomena of sensemaking have been approached from different points of view. These can be organized according to the time scale for the process and whether the process involves individuals or organizations (Thomas & Cook; Leedom, 2001). At the time scale of months, and at the organizational level, Weick (1995) argues that the social dynamics of organizational processes are based on sensemaking. A set of "mental minimal sensible structures" together with goals lead to the creation of situational understanding and direction for members of an organization. At the time scale of minutes or hours, and at the individual level, Klein (1989, 1998) has developed a model of recognition-primed decisions making. This model emphasizes the role of knowledge structures resulting from experience and expertise. These knowledge structures or "frames" govern expectations and perceptions and allow a soldier or firefighter to make sense of a situation. They allow the rapid formulation of an action based on the perceived features of a situation or even their lack. At the level of time scale of seconds or minutes, Endsley (1995) and others have studied sensemaking as the achievement of situation awareness, particularly for jet fighter pilots in air combat. Situation awareness is the achievement of perceiving elements of the environment, comprehending their collective meaning, and projecting their status into the near future.

Intelligence analysis is an obvious form of sensemaking. Studying occupational experts of an activity is a classical method for understanding the structure of that activity (Bryan & Harter, 1899). Studies of intelligence experts (Krizan, 1999) remind us that intelligence analysis covers a number of different activities. Such studies have often been prescriptive or at an ethnographic level (Johnston, 2005). The purpose of this study is gain insight into the sensemaking process by tracing user process and knowledge through a reasonable approximation of an analyst's task. The study, which takes advantage of data collected for a government research program, is focused at the scale of days and at the level of an individual.

THE STRUCTURE OF SENSEMAKING
While sensemaking might seem like a vague concept, our earlier attempt to study sensemaking suggested that there is a relatively well-defined structure to the phenomenon. The task studied involved a corporate training department creating a curriculum on printing technology. The various activities of the department could be summarized in terms of two processes: (1) searching for a representation or framework scheme and (2) actually filling in the framework with the data collected on printers. Attempting to fill in the framework would end with some data residue, which didn't fit, which would lead to a shift in the representation and

then another attempt to fill it in with the data. We call this basic model a *learning loop complex* (Russell, et al. 1993).

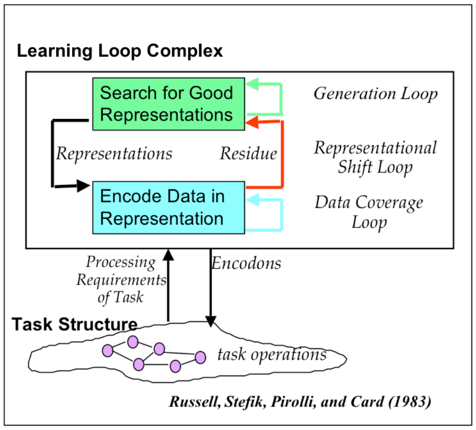

Figure 1. Learning Loop Complex

Card et al. (1999) used an elaboration of this model to define the concept and process of information visualization. We have also found that a version of the model seems to summarize the basic process of some intelligence analysis (Pirolli & Card, 2005; Cook & Thomas, 2005). Fig. 2 shows a notional model of intelligence analysis. This model extends out from the activities of the Learning Loop Complex to include information acquisition and report production. Boxes in the diagram represent data and arrows represent processes. An analyst through filtering of message traffic and active search (1) collects information into an information store or "shoebox" (4). Snippets of this evidence are collected into another store or "evidence file" (7). Information from this evidence may be represented in some schema or conceptual form (10) (the framework of the Learning Loop Complex model), such as laying it out on a timeline, or the schema may be just mental. This organization of information is used to marshal support for some story or set of hypotheses (13). Finally the information is cast into an output knowledge product, such as a briefing or a report (16).

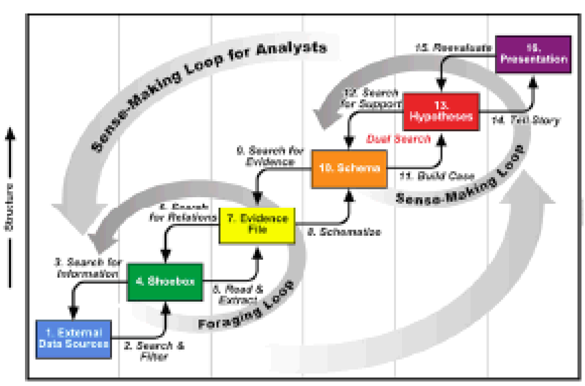

Figure 2. Notional Model

The process is not straight forward, but can have many loops. It can be driven from the bottom up, making sense of the data, or it can be driven top down from hypotheses, most likely a combination of both. There are two definable principal loops: (A) an information foraging loop, concerned with the gathering and processing of data to create schemas and (B) a sensemaking loop, concerned with the processes involved in moving from schemas to finished product.

Klein et al. (2007) come to a similar conclusion. His model of the process is based around the data/frame, a mental structure that organizes data, and sensemaking is the process of fitting information into that frame. Data/frames are a consequence of developed expertise.

METHOD

In this study, intelligence analysts were given tasks that resembled routine intelligence requests. They were watched by observers, who took notes. Their actions were also automatically recorded by a "Glass Box" program.

Participants

Here we report preliminary results from two analysts, one a senior analyst with seven years experience and one a more junior analyst with one year of experience.

Tasks

Participants were asked to engage in typical intelligence exercises, using only publicly available information about former Cold War matters and events such as assessments of foreign military capabilities in the past. No classified data or systems were used. Participants were given paragraph-long "taskers" that resembled intelligence analysis requests from clients. All required some form of written deliverable to answer the tasker question(s). Some taskers required quick turn-around times (e.g., one or two days) while others involved more long-term analysis (e.g., several weeks). As in real intelligence analysis situations, different taskers were assigned to different analysts at any given time. To enrich the scientific analysis of such intelligence analysis activities, each tasker was given to several analysts at different points in time so that individual behaviors could be observed across identical tasks.

Participants

Intelligence analysts are a prime population for studying sensemaking processes, as they are professional sensemakers. Participants consisted of senior and junior intelligence analysts doing taskers for over a year, using various methods of data collection. As a starting point for analyzing this rich data set, the current analysis focuses upon the comparison of two intelligent analysts—one of each level of expertise—doing shorter-term taskers.

Data and analysis

At the highest level of analysis, participants were observed doing their taskers and time-stamped notes were taken about the activities of these analysts minute-by-minute throughout the workday. At the end of each day, observers summarized the day with qualitative descriptions.

At the lowest level of analysis, participants' behaviors on their computers were logged using a system called Glass Box. Glass Box collected second-by-second time-stamped data. Such data included every application launch, search term, web page URL, copied and pasted contents, etc. This data was later filtered, time synced with observational data, and coded using cognitive task analysis operators.

Some tasks were completed without aid from Glass Box so the analyst would provide documents and approximate time stamps for activities. Follow-up interviews were conducted and transcribed to obtain expansion of details from such documents.

RESULTS

Operators

Through an iterative analysis of these data, we generated a taxonomy of operators for categorizing intelligence analysis behaviors. This taxonomy included operators in four overlapping high-level categories: foraging, sensemaking, planning, and helping. We here list the high-level categories and the specific operators within each category.

- FORAGING: accessing, consulting, following pointers, searching, translating, skimming, reading
- SENSEMAKING: skimming, reading, gathering, structuring, annotating, formulating, building propositions, composing, reviewing, testing hypotheses
- PLANNING: planning analyses, planning subjunctives
- HELPING: helping, consulting others

We found this set of operators to be reasonably comprehensive for coding the intelligence analysis behaviors across multiple study participants doing a wide variety of tasker types. The operators were used to generate the analysis shown in Figure 4. Initials for the operators are used to represent each operator type, which are associated with each arrow, moving from one data type to the next.

Process Flow

The general process flow of the junior analyst is described schematically in Figure 3. The analyst would skim the information provided until he found a hit, then he would gather in that hit and process it. Eventually he had enough to compose his report. The analyst had at least three major types of activity in which he was simultaneously engaged: (1) foraging for information, (2) composing that information ("sensemaking" proper), and (3) monitoring for new incoming information or fielding interrupts from other colleagues.

In Figure 4, we expand out the process for both of the analysts and show it in more detail. The loops are unraveled so as to form a set of horizontal sequences expanding downward.

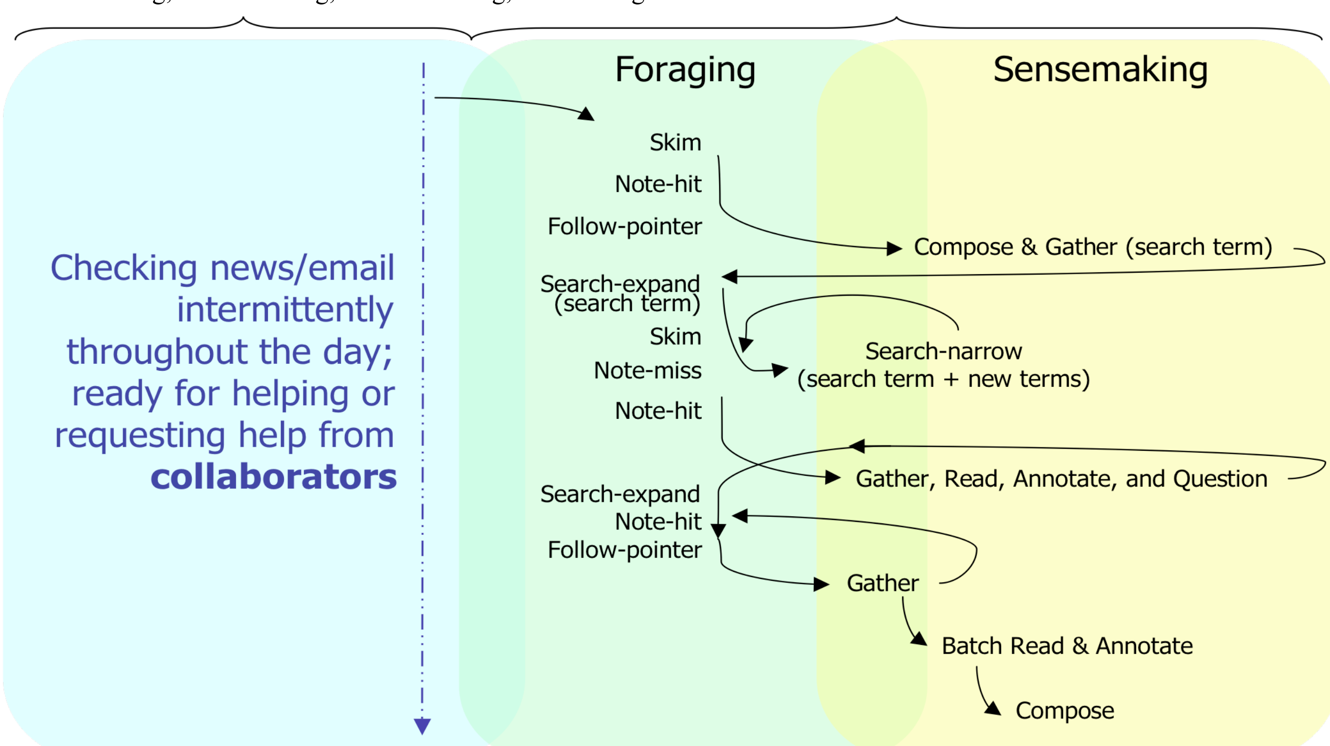

Figure 3. Generic process flow for junior analyst with time progressing downward, depicting three parallel intelligence analysis activities

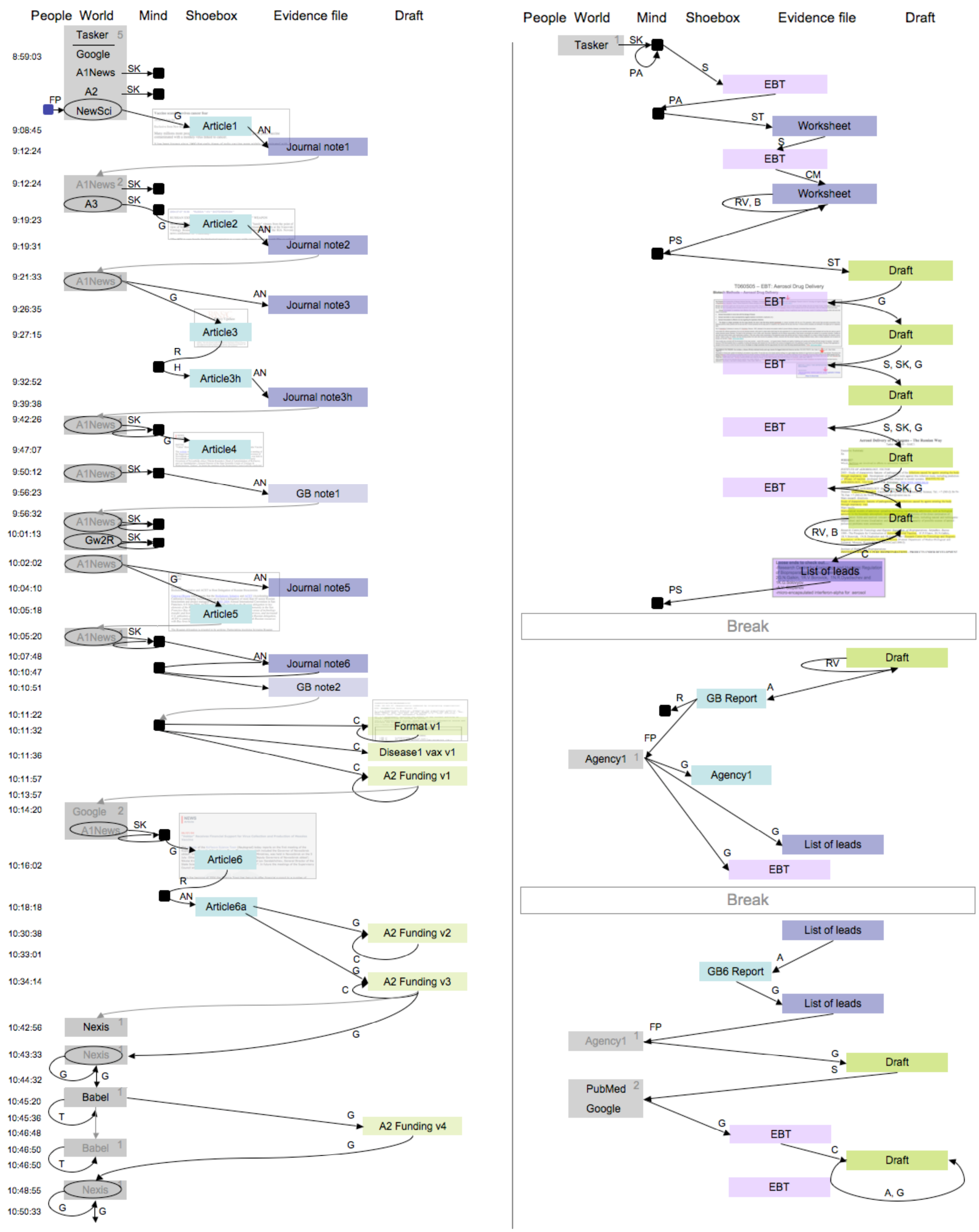

Figure 4. Comparison of junior (left) vs. senior (right) intelligence analysts' sensemaking behaviors over time (vertical dimension) through varying data types (horizontal dimension)

Knowledge Unit Tasks

In our task analyses, several patterns of operator loops emerged. We refer to these as types of *knowledge unit tasks*. The rough idea is that sensemaking occurs as a number of discreet cycles, the knowledge processing analog to unit tasks (Card, Moran, & Newell, 1983). Approximately, these consist of cycles in Figure 3. Tentative examples of such units include:

- EXHAUSTIVE FORAGING: Reaching out to distant information patches, scouring them for leads, and gathering useful bits; access-search-skim-[repeat until note a lead]-gather-annotate-[repeat]
- STRATEGIC FORAGING: Foraging most familiar information patches (e.g., personal information repositories) before ever reaching out to more distant patches; search (personal documents)-gather-[repeat until exhausted]-search (other sources)
- EVIDENCE MARSHALLING: Starting from the task of composing, the analyst engaged in directed foraging for supporting evidence; compose-search-gather-[repeat]
- MAINTAINING SITUATION AWARENESS: Intermittently checking on the same information patch(es) to remain up to date about a subject; access-skim-[repeat]

Time-based analysis

With the junior analyst, for whom we could infer approximate characteristic times for the knowledge unit tasks of about 12 minutes (M=12m 13s, SE=2m 9s). We can also analyze the contribution of some of the sub-activities. For example, the junior analyst spent an average of 26 seconds (SE=5.1 seconds) on each gathering activity and an average of 17 seconds (SE=5.6 seconds) on each annotating activity.

Being able to chunk low-level behaviors into knowledge assembly loops also allows for the analysis of frequencies and sequences of sensemaking behavior. For example, the junior analyst reported here went through a total of seven exhaustive foraging loops before beginning to compose any notes or drafts for the final report. After that, this analyst went through ten evidence marshalling loops, interrupted only by one situation awareness maintenance loop and one reach out to a colleague for assistance (consult). In contrast, the senior analyst reported here went straight to strategic foraging and evidence marshalling at the very start of his analysis, spending the vast majority of his time in evidence marshalling loops. This contrast is visible in the current analysis, comparing the junior against the senior analyst's behaviors; see Figure 4.

Data flow

As sensemakers construct their own personal information patches (e.g., shoeboxes of files, notebooks), they create repositories that allow them to be more prepared for future taskers. Such construction of personal information patches takes on the form of data flows from external information sources to increasingly personal ones. For example, a web page found on the Internet might be saved as a file in one's repository of useful documents (shoebox); the useful paragraph in the web page might be copied and pasted into one's file of notes (note book); or the useful summary and interpretation of the paragraph's contents might be added to one's draft of a final report (draft). These types of gathering demonstrate increasing degrees of personal incorporation of the information and increasing use of schemas for organizing and making sense of the information. As the amount of personally constructed information increases, one has a more readily available information patch from which to forage before reaching out to more external sources. Seniors are more likely than juniors to have such rich personal information patches. Increasingly personal data types are depicted in this analysis by the horizontal dimension of Figure 4.

Senior vs. junior behaviors

From our analyses of senior and junior analyst behaviors, a general trend of more top-down behavior in seniors and more bottom-up behaviors in juniors has become apparent. Senior analysts begin with their own hypotheses and large personal repositories of information before reaching out to more distant sources to fill in gaps or get updates. Junior analysts begin with limited personal repositories of information and, therefore, engage in exhaustive foraging of distant sources before forming hypotheses. Differences in more bottom up vs. top down approaches are apparent in the current analysis in where the analyst starts the process, either doing exhausting foraging from the far left first (bottom up) or jumping to personal information patches and composing first (top down) in Figure 4.

DISCUSSION

This generation of operators for intelligence analysis, knowledge assembly units, and time- and sequence-analyses of junior and senior intelligence analysts aim to take first steps toward an increasingly thorough understanding of the general sensemaking process.

Furthermore, this investigation aims to identify leverage points from which new practices or technologies might be introduced to support and improve sensemaking processes. By continuing to analyzing more participants, doing identical taskers, we seek more generalizeable characterizations of sensemaking behaviors through systematic cognitive task analyses. The notable differences in junior vs. senior analyst behaviors suggest that different tools might be recommended for different degrees of expertise. They might even be used to help encourage more expert-like behaviors in junior analysts.

Using time- and sequence-based analyses, we may identify the operators and knowledge assembly units that tend to take the most time or tend to occur in batches that may be aided by supporting technologies. The junior analyst's gathering and translating behaviors seen in Figure 4 suggest the need for more automated document translation. The senior analyst's heavy use of his own personal knowledge repository (EBT) suggests the need for more support on the side of personal knowledge repository creation and search.

While this series of analyses currently focuses upon intelligence analysts, we believe that these conceptual tools will be of use to the broader population of people who generally need to cope with vast amounts of information and limited amounts of time and cognitive resources.

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