# A framework of Distributed Sensemaking in investigations

Ashley J. Wheat
Interaction Design Centre
Middlesex University, London, NW4 4BT, UK
*a.wheat@mdx.ac.uk*

**This paper reports the work involved in the development of the distributed sensemaking framework. The framework serves as a mechanism to describe the appropriation of elements of the distributed cognitive system in support of sensemaking in investigatory activities. Here we outline the work leading to the formulation of the distributed sensemaking framework and implications for the design of new technologies.**

*Distributed cognition, sensemaking, investigations, collaboration, intelligence analysis, Big Data*

## 1. INTRODUCTION

Following a huge shift in the way we communicate (Attfield and Blandford 2010), we are leaving more of an electronic footprint than ever before. Moreover, in an age of Big Data (Mayer-Schönberger and Cukier 2013), the volume and complexity of data is increasing exponentially, placing ever greater demand on investigators and intelligence analysts using it for their work.

Though computers provide a vital resource in organising and structuring, filtering and sorting data quickly and efficiently, sensemaking is a predominantly human-centred activity; computers lack the ability to provide interpretation, meaning or insight to data (Andrews et al. 2010). Moreover, sensemaking not only takes place in the head of the investigator, but can be extended into the world across a number of actors, resources and objects in physical space. Following the notion that human cognition is 'distributed' (Hutchins 1995a,b) we argue that access to electronic resources and computational power is restricted by the limitations of current computer interfaces and interaction methods.

### 1.1. Distributed cognition

Distributed cognition (DC) encompasses the distributed nature of cognitive processes that take place between people, objects and internal and external representations. It seeks to apply the traditional cognitive science theory to larger cognitive systems outside of the individual—extending the scope to the interaction of people, resources and the environment to perform some task (Rogers 2006; Hollan et al. 2000; Rogers 1997).

### 1.2. The Resources Model

Wright et al.'s The Resources Model (RM) provides a language and set of concepts for HCI researchers to study and articulate DC concepts in a way that can practically applied to HCI research where DC lacks any set of categorical features to make it useful as a "quick and dirty" research method (Rogers 2005; Wright et al. 1996, 2000).

RM models external cognition as a set of *resources* that are drawn upon during user interaction. Resources are classified as *plans, goals, possibilities, history, action-effect relations* or *states*, represented internally or externally, informing action (Rogers 2005, 2012). The composition of resources are a result of *interaction strategies* such as *plan following* and *goal matching*. RM comprises of two central components: the characterisation of information structures connected to the control of action, and the process-oriented, cyclic translation of these information structures as resources for action.

### 1.3. Sensemaking

Sensemaking is the process in which people gain understanding and meaning from external information and collections of data (Andrews et al. 2010). It is the result of a synergy between information, interpretation and action, and has been used to describe how the acquisition of information is used to support activity.

Klein et al. (2006) offer The Data-Frame Theory as a macrocognitive theory describing the interaction of *data*, information about the world and *frames*, the sensemaker's internal representation of this. Pirolli and Card (2005) offer a different, notional model of sensemaking describing a cyclic process involving representations of information in schemata and the manipulation of schemas to gain insight forming some knowledge or understanding.

### 1.4. Research overview

This work addresses the notion that DC is a key supporting component in sensemaking for those carrying out investigations. This paper describes the work carried out leading to the contribution of the distributed sensemaking framework (DSF) and the implications this has on the design of technologies supporting investigatory activities. The thesis of this work is driven by driven by three core questions:

1. (a) How do analysts carrying out investigations appropriate the affordances of physical space, materials and resources in service of sensemaking?
   (b) How do analysts carrying out investigations appropriate the affordances of physical space, materials and resources to support collaboration?
2. What are the design implications for the development of novel technologies and tools supporting distributed sensemaking?

## 2. METHODOLOGICAL APPROACH

### 2.1. Early observations

The initial stage of this scheme of work saw the observation of domain experts (intelligence analysts) performing training exercises in communications intelligence scenarios. An informal analysis of observations and accompanying interviews and focus groups pinpointed some key themes and phenomena pertaining to the notion of distributed sensemaking.

### 2.2. Exploratory studies into distributed sensemaking

A number of exploratory studies were carried out under varying conditions. These studies saw participants carrying out simulated investigations using a fictitious data set relating to a crime scenario. Participants were provided with resources typical to that of a real world investigation environment (such as post-it notes and whiteboards) and asked to carry out an analysis of the data in order to produce a hypothesis. Studies were carried out with participants working individually and collaboratively. Additionally some individuals and groups were provided with computers running INVISQUE (Wong et al. 2011), which supports active visual search and query of data using visual metaphors to support analysis and evaluation.

Data from these studies were collected in the form of observational notes, video recordings and photographs. A contextual task analysis helped understand participant's actions from their own perspective. Data was analysed by means of a thematic analysis framed in part by a combination of the findings of early observations, RM and sensemaking theory.

### 2.3. Development of a framework and design implications

Following the analysis of findings from preceding elements of this research, a systematic attempt was made to describe observed phenomena through the application of elements of RM and sensemaking theory. Through the extension and revision of RM and its symbiosis with sensemaking models we were able to produce a series of concepts in the form of a framework describing distributed sensemaking. This also led to a number of design implications.

The framework was validated in the following ways: empirical experiments were carried out testing hypotheses articulated through DSF. Findings were articulated through DSF and its effectiveness in this observed. A second validation saw the systematic review of DSF by independent subject experts in HCI, DC and sensemaking. Prototype technologies were developed embodying design implications described by DSF and evaluated in a series of empirical experiments.

## 3. CONCLUSION

This paper reports work delivering a conceptual framework describing the dimensions of distributed sensemaking. DSF provides a set of concepts and a language to articulate the appropriation of elements of the distributed cognitive system in support of sensemaking tasks in investigatory activities.

DSF not only serves as a mechanism for analysis, but provides HCI researchers and practitioners with a set of concepts giving insight to the design and evaluation of technologies to assist investigatory work involving large volumes of diverse and complex data, as demonstrated by the development of prototypes in this work. This is a particularly timely contribution in our emergent era of Big Data.

## REFERENCES

Andrews, C., A. Endert, and C. North (2010). Space to think: large high-resolution displays for sensemaking. *. . . of the SIGCHI Conference on Human . . .*, 55–64.

Attfield, S. and A. Blandford (2010). Discovery-led refinement in e-discovery investigations: sensemaking, cognitive ergonomics and system design. *Artificial Intelligence and Law*, 1–20.

Hollan, J., E. Hutchins, and D. Kirsh (2000, June). Distributed cognition: toward a new foundation for human-computer interaction research. *ACM Transactions on Computer-Human Interaction 7*(2), 174–196.

Hutchins, E. (1995a). *Cognition in the Wild*, Volume 262082314. MIT press Cambridge, MA.

Hutchins, E. (1995b, July). How a cockpit remembers its speeds. *Cognitive Science 19*(3), 265–288.

Klein, G., B. Moon, R. R. Hoffman, and K. Associates (2006). A Macrocognitive Model Human-Centered Computing A Macrocognitive Model. *21*(5).

Mayer-Schönberger, V. and K. Cukier (2013). *Big data: A revolution that will transform how we live, work, and think*. Houghton Mifflin Harcourt.

Pirolli, P. and S. Card (2005). The sensemaking process and leverage points for analyst technology as identified through cognitive task analysis. In *Proceedings of International Conference on Intelligence Analysis*, Volume 5, pp. 2–4.

Rogers, Y. (1997). A brief introduction to distributed cognition.

Rogers, Y. (2005, September). New theoretical approaches for human-computer interaction. *Annual Review of Information Science and Technology 38*(1), 87–143.

Rogers, Y. (2006). Distributed cognition and communication. *Encyclopedia of Language & Linguistics*, 2731–2733.

Rogers, Y. (2012). Hci theory: classical, modern, and contemporary. *Synthesis Lectures on Human-Centered Informatics 5*(2), 1–129.

Wong, B. W., S. T. Choudhury, C. Rooney, R. Chen, and K. Xu (2011). Invisque: technology and methodologies for interactive information visualization and analytics in large library collections. In *Research and Advanced Technology for Digital Libraries*, pp. 227–235. Springer.

Wright, P. C., B. Fields, and M. D. Harrison (1996). Distributed information resources: A new approach to interaction modelling. In *Proceedings of ECCE8: Eigth European Conference on Cognitive Ergonomics*, pp. 10–13.

Wright, P. C., R. E. Fields, and M. D. Harrison (2000). Analyzing human-computer interaction as distributed cognition: the resources model. *Human-Computer Interaction 15*(1), 1–41.