Sensemaking in Symbiotic Joint-Cognitive Systems

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INTRODUCTION

A joint-cognitive system is a system of two or more reasoners (cognitive entities) in which the impetus for the output of such a system to act is reached through cooperation, collaboration, or non-cooperation of the various reasoners. This is often referred to as an agency, regardless of the constituents. For the sake of this discussion, we define a symbiotic system to be a joint-cognitive system in which a human reasoner and a human-centered agency called an associate system have a tightly coupled interaction loop, cooperate, and collaborate effectively in agency [Singletary and Starner, 2001]. The effort produced by both entities in interaction hopefully yields a net benefit. This paper includes some observations on how sensemaking occurs in such joint-cognitive systems.

Though founded in corporate organizational structure and classic organization theory, the relevance and applicability of sensemaking are not limited to those fields. For example, sensemaking has been identified and studied as a critical technology for automation and support requirements in military environments [Leedom, 2001] resulting in strong taxonomies relevant to that field. Sensemaking is very relevant to the computer human interface problem. It is our position that sensemaking is an important part of a larger cognitive process situated in a dynamic 'social' landscape. The concept of sensemaking is crucial to the design and understanding of most collective reasoning experience support tools. Further, automation in user interfaces must take into account how a user will ultimately perceive, incorporate, and exploit information presented to them, regardless of modality, or the user's experience with the interface will seem disjoint and therefore less valuable.

BACKGROUND ON SENSEMAKING

Sensemaking is viewed as a retrospective thinking process to explain surprise [Louis 1980]. It is a continuous recurring cycle consisting of events occurring over time that begins as individuals form unconscious and conscious anticipations and assumptions to predict future events. This cycle ends as meanings are assigned to surprising events. According to Starbuck and Milliken, sensemaking involves placing stimuli into a familiar frame of reference [Starbuck and Milliken 1988]. This interplay of perception, action and interpretation suggests that explicit efforts of sensemaking occur when the state of the world is ambiguous. Neisser's 1967 perceptual cycle (see figure 1) illustrates how schemas aid interpretation [Neisser 1976]. A schema is an organization of experience that serves as an initial frame of reference for action and perception. "[A schema] directs the exploration of objects, this exploration samples portions of an object, and these samples may modify the schema, which then directs further exploration and sampling, which then further modified the schema; this kind of process goes on continuously" [Weick 1979]. Interpretation, not choice, is the core phenomenon, when action is the main focus [Laroche 1995, Lant 2002, Weick 1993].

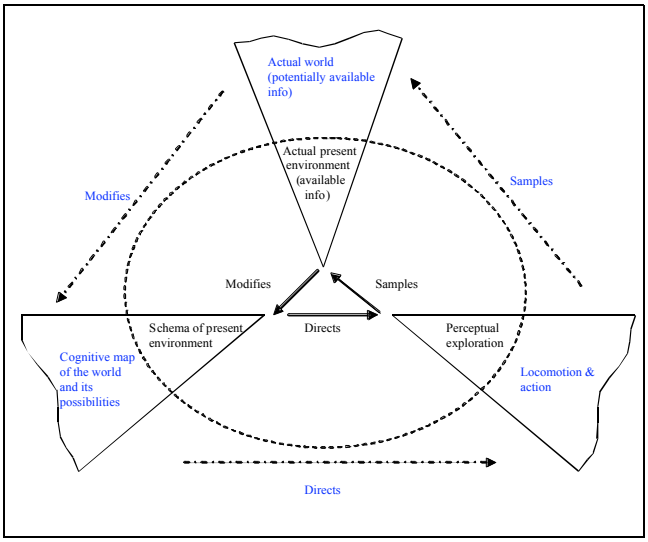

Figure 1: illustrates how schemas aid interpretation

Thomas, Clark and Gioia describe sensemaking as "the reciprocal interaction of information seeking, meaning ascription, and action" (Gioia et al. 1993). Focused on equivocal process-making, sensemaking gives the search for meaning as a way to deal with uncertainty a priority (Mills 2003).

Uncertainty is a state attributed to an interactive environment by an acting body. Depending on the type and structure of this acting body (e.g. whether an individual human agent, or a group of human agents, or other heterogeneous groups), the explicit sources of uncertainty become equivocal. The concept and process of sensemaking, therefore, change accordingly. An issue that immediately surfaces is related to boundary conditions of collective structures, how they form and norm including dynamics of membership and separation. Allport argued that human agents converge first on issues of means rather than issues of ends. They agree first on how a structure can form then they will engage in repetitive series of interlocked behavior, forming collective structures [Allport 1962]. "[Human participants] in a collective structure share space, time and energy, but they need not share, visions, aspirations, or intentions. That sharing comes much later, if it ever comes at all" [Weick 1979]. Sensemaking becomes necessary in defining boundary conditions for a group. Sackman discusses mechanisms that organizational members use to attribute meaning to events to facilitate sensemaking [Sackman 1991]. Feldman [1989] talks about sensemaking as an interpretive process that is necessary "for organizational members to understand and to share understanding about such features of the organization, what is it about, what it does well and poorly, what the problems it faces are, and how it should resolve them."

Equivocality and uncertainty drive the need for sensemaking. These two concepts change in complexity from an individual process of sensemaking into collective. However, before discussing sensemaking in collective structures, a summary of properties of sensemaking is outlined. Weick (Weick, 1995, forthcoming) presents sensemaking, mainly individual, as having seven basic properties, thus requirements for a formal system description:

1. **Identity:** The recipe is a question about who I am as indicated by discovery of how and what I think.
2. **Retrospect:** To learn what I think, I look back over what I said earlier.
3. **Enactment:** I create the object to be seen and inspected when I say or do something.
4. **Social:** What I say and single out and conclude are determined by who socialized me and how I was socialized, as well as by the audience I anticipate will audit the conclusions I reach.
5. **Ongoing:** My talking is spread across time, competes for attention with other ongoing projects, and it reflected on after it is finished, which means my interests may already have changed.
6. **Extracted cues:** The "what" that I single out and embellish as the content of the thought is only a small portion of the utterance that becomes salient because of context and personal dispositions.
7. **Plausibility:** I need to know enough about what I think to get on with my projects, but no more, which means sufficiency and plausibility, take precedence over accuracy.

SENSEMAKING IN SYMBIOTIC SYSTEMS

We define a symbiotic system to be a joint-cognitive system in which a human reasoner and a human-centered agency called an associate system have a tightly coupled interaction loop, cooperate, and collaborate effectively in agency [Singletary and Starner, 2001]. Figure 2 shows a high level view of a symbiotic system. We consider the associate system relationship to have properties and requirements that differ it from typical agent based interfaces. Characteristics include increased speed of interaction, much more personal or invasive sensors and actuators, and consequences for the human upon a misunderstanding between entities. Usually, the system will be partially integrated with or in close physical and cognitive proximity to the human reasoner and their task (ex. a fighter cockpit system, most wearable computers, soldier or police combat gear). Therefore, the physical sensors and actuators of the proximate system are generally captive, after a fashion, to the human purpose, perspective, and task.

Since, like a typical agency, we assume the presence of cognitive cycles in members of the symbiosis, both human and associate system sense, sensemake, plan, coordinate, and act in their own right. Therefore, when a surprising stimulus arrives, the system is subject to sensemaking processes in three parts: human, associate, and the symbiotic system as a whole. As the human and associate physical sensory input overlaps from the perspective of the human, the associate is said to share experience with the human. The human can be expected by the associate to interact with environmental stimuli. This does not preclude the value or use of virtual or distant sensors and actuators by the agency. But shared experiences provide a point of opportunity for synchronization of the associate sensemaking process to that of the human.

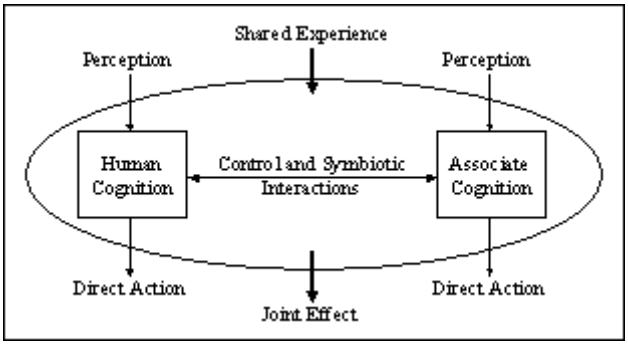

Figure 2: Symbiotic system with human and associate.

By definition, the joint effect actuated by the symbiotic system will be of greater benefit to the human than a disjoint or more loosely integrated system. This is one of the many definitions of collaboration (Ferber, 1995). The continuous interaction between human and associate system would consist of actions like nonverbal behavior, commands, control, and proposals. The individual interactions vary in their explicitness when communicated. It is advantageous if the amplified or augmented joint effect of the system could be achieved for fewer and simpler interactions from human to associate and vice versa.

It is our position that as the synchronization between sensemaking processes becomes tighter, the more likely the associate system can recognize the state of the human activity and therefore autonomously take actions that benefit the human in the context of that activity. This is because one can assume the associate system to have similar instantaneous and historical context it can leverage to reduce uncertainty in interpretation. Therefore, it is also our position that construction of human-associate interactions that yield a Net Benefit (Buxton, 2001) to the human relies on conscious design to synchronize the sensemaking processes of individual units.

To that effect, the associate system can be designed to provide amplification and augmentation of cues processed by the human. For example, avoiding user task interruption can enhance continuity in sensemaking (Kern et. al., 2004). The associate system can perform this in situations where it has a both models of situation and activity, and sensemakes based on the same data available to the human. The interaction pattern of the human can also be designed to be simultaneously natural and contain control information that shapes the associate system's sensemaking process. Thus the human can posture themselves and their interactions to the aid of the associate system (Lyons et. al, 2004). Such processes are mutually beneficial to synchronization of individual sensemaking processes.

Weick makes an interesting observation that highly evolved relationships result in predominately negative feedback between the entities. It may be the case that such a system, if highly evolved, would result in more autonomous behavior than described above. The human would likely be given the chance to override the wearable and similarly the wearable would be given the chance to warn the human of the negative consequences of their actions.

BIOGRAPHIES

Bradley Singletary is an embedded systems engineer experienced at building intelligent systems software for ubiquitous computing environments, wearable computers, handheld computers, imaging check reader terminals, and conference badge systems. Brad has a background in automatic social situation understanding by wearable computer. Brad currently serves in a technology lead at Applied Systems Intelligence, Inc. Applied Systems Intelligence, Inc. (http://www.asinc.com) produces and sells an associate systems construction framework called PreAct® that models a symbolic cognitive reasoning process. PreAct is a good framework for nontrivial intent interpretation and intent inference tasks by machine. Since it models activities, has situation assessment facilities, has planning/coordination facilities and can take action, PreAct can represent and support associate system interface construction.

Newton Howard is a professor at the George Washington University at which he founded and chairs the Center For Advanced Defense Studies. He holds Doctorates from Oxford and La Sorbonne as well as the Research Habituation from La Sorbonne. Newton is an expert on intent theory and intention awareness in their various application domains. He has applied his theories on sensemaking and intent to various intelligence related domains including the DHS and terrorist intent. Newton's biography is extensive and may be found online at: http://www.c4ads.org.

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