Developing Narrative Theory for Understanding the Use of Story in Complex Problem Solving Environments

Stephen M. Fiore
University of Central Florida
3100 Technology Parkway
Orlando, FL 32826
sfiore@ist.ucf.edu

Rudy McDaniel
University of Central Florida
12461 Research Parkway
OTC500 Room 144
Orlando, FL 32826
rudy@mail.ucf.edu

Michael Rosen
University of Central Florida
3100 Technology Parkway
Orlando, FL 32826
mrosen@ist.ucf.edu

and

Eduardo Salas
University of Central Florida
3100 Technology Parkway
Orlando, FL 32826
esalas@ist.ucf.edu

ABSTRACT

In this paper we argue that theory and methods from the cognitive and organizational sciences can be integrated with principles of narrative theory in order to produce a fuller understanding of some of the macrocognitive processes involved in problem solving. We first discuss the development of the macrocognition construct in naturalistic research environments and briefly discuss how story has been used in naturalistic decision making theories. We then provide a brief explication of narrative theory to highlight its multifaceted nature. Last, we discuss how a set of the foundational features of narrative may be used to support problem solving in complex environments.

Keywords

Narrative, problem solving, Macrocognition, story

INTRODUCTION

During the past decade a significant epistemological mingling between the cognitive and organizational sciences has substantially influenced this study of teams and it has been over a decade since the original applications of constructs from cognitive psychology were utilized to foster the development of the team cognition movement in naturalistic decision making (NDM) research (e.g., Cannon-Bowers & Salas, & Converse, 1990; Hutchins, 1991; Orasanu, 1990; Rouse, Cannon-Bowers, & Salas, 1992). Since then, much cross-disciplinary attention has focused on determining how cognition contributes to effective collaboration. What is invariant across these disciplines is the notion that shared information processing among group members has both inter- and intra-individual outcomes (e.g., Engestrom & Middleton, 1996; Rouse et al., 1992), whereby constructs such as encoding, storage, and retrieval of information are thought to be equally applicable to both individuals and groups (e.g., Hinsz, Tindale, & Vollrath, 1997; Klein & Zsambok, 1997; Larson & Christensen, 1993; Thompson, Levine, & Messick, 1999; Tindale & Kameda, 2000). Although the issues surrounding our understanding of cognition in teams in naturalistic settings are far from resolved, this movement has made substantial strides in our understanding of performance (e.g., Salas & Fiore, 2004).

Despite this progress, we argue that theory and methods from the cognitive and organizational sciences can be integrated with principles of narrative theory in order to produce a fuller understanding of problem solving in naturalistic environments. In particular, as in recent movements linking NDM with organizational decision making (see Lipshitz, Klein, & Carroll, 2006), we suggest that NDM would similarly benefit from consideration of theories emerging from other disciplines such as narratology (e.g., Bal, 1997; Onega & Landa, 1996). As such, in this paper we discuss how such an integration can proceed and emphasize its benefit to understanding macrocognition. In the following sections we first discuss the development of the macrocognition construct in naturalistic research environments and briefly discuss how story has been used in theories arising from NDM. Second, we provide an explication of narrative theory to highlight its multifaceted nature. Last, we discuss how the features of narrative may be used to support problem solving in complex environments.

DEVELOPMENT OF THE MACROCOGNITION CONCEPT

Across a small number of scientific disciplines, the term macrocognition, when contrasted with the term microcognition, has been used to describe a variety of cognitive phenomenon. First, in cognitive science, and primarily in the context of connectionism, researchers state that macrocognition refers to "those processes, such as reasoning and communication, where analysis does not take place at the level of the single processing unit. At these high level cognitive domains, analysis and simulation do not concern the *individual behavior of each neuron, but the functioning of the mind as a whole*" (Bara, 1995, p. 77, emphasis added). Within cognitive engineering theorists have proposed the term "macrocognition" to describe how cognition emerges in natural environments. This line of thinking is essentially based upon the work of Cacciabue and Hollnagel (1995) who proposed the term "macrocognition" to describe how cognition emerges in natural environments and "the study of the role of cognition in realistic tasks, that is, in interacting with the environment" (Cacciabue & Hollnagel, 1995, p. 57). Klein and colleagues (2003) similarly argued that contextually bound cognitive processes (e.g., sense making, uncertainty management) must be studied in natural settings (Klein et al., 2003). These are environments in which complex and emergent cognitive processes arise (i.e., macrocognitive processes), as opposed to "micro-cognitive" processes described as cognition used in laboratory studies.

More recently, the term macro-cognition has been adopted to capture cognition in collaborative contexts. In their theoretical and empirical analysis of collaborative problem solving, Warner, Letsky, and Cowen (2005) argue that macrocognition encompasses both internalized and externalized processes occurring during team interaction. Letsky and colleagues (Letsky, Warner, Fiore, Rosen, & Salas, 2007) have elaborated on this further and define macrocognition as the internalized and externalized high-level mental processes employed by teams to create new knowledge during complex, one-of-a-kind, collaborative problem solving. They describe "high-level" as cognitive processing involved in the combining, visualizing, and aggregating of information to resolve ambiguity in support of the discovery of new knowledge and relationships. More specifically, internalized processes can occur at either the individual or team level but they can only be assessed using indirect techniques such as qualitative metrics like cognitive mapping or think aloud protocols or by using surrogate quantitative metrics such as galvanic skin response. Letsky et al. (2007) define externalized processes as those higher-level mental processes which occur at the individual or the team level, and which are associated only with actions that are observable and measurable in a consistent, reliable, repeatable manner or through the conventions of the subject domain having standardized meanings. These are used by teams in complex environments where collaborative problem solving focuses on one-of-a-kind situations (e.g., Non-combatant Evacuation Operations). It is this problem solving context on which we focus to show how macrocognitive theory can be augmented with concepts from narrative theory.

REPRESENTING REALITY

Perhaps humankind's greatest accomplishment has been the multi-faceted ways it has developed to represent reality (Donald, 1991; Norman, 1993). We have developed four primary representational systems through the ages to convey a myriad of conceptual and emotional understanding of our world. First would be the visual or pictorial where images are used to capture some phenomenon. From the first cave paintings to the literal interpretations of the renaissance artist to the abstract forms of modern art, images varying in complexity and meaning have been developed to help us understand and interpret the world around us. Additionally, we have invented mathematical systems as the symbolic tools to help us account for and predict the abstractions of the physical world. Music has been a potent means through which we have been able to capture the emotional and affect laden aspects of our existence. But it is narrative that is perhaps at the forefront of being able to effectively convey a complex reality. When done well, narrative is able to capture and convey not only the evocative but the cognitive complexities we experience as we interact with our world. Interestingly, in the context of problem solving and decision making, we have seen narrative, imagery, as well as mathematics utilized in some way. The NDM community favored both the narrative and the visual form over the mathematical and algorithmic means of decision making (we've yet to see music used in NDM, but, the discipline is still young…). But, just as the visualization tools for decision making are increasing in sophistication, we suggest that the use of narrative in NDM similarly increase in maturity.

Storytelling and narrative have long been used in organizations to convey notions of culture and organizational experience (e.g., Feldman, 1990; Fiore & McDaniel, 2006; Smith & Keyton, 2001) and we suggest that *team problem solving* can be more effective and more memorable when transported through narrative. In particular, narrative allows for an elaboration of three interrelated dimensions – *Social, Cognitive* and *Affective* – that have the potential to create a powerful problem solving context. From the social perspective, Bruner (1991) suggested that narrative is inherent to human existence, arguing that we create internal representations of social interactions and human experience using forms of narrative and story for representing and organizing these activities. Others have argued that the narrative form may be one of the earliest means for retaining knowledge and for passing that knowledge on to future generations (e.g., Bal, 1997; Dautenhahn, 2003; Denning, 2001; Snowden, 1999). Cognitive research has explored how humans find it natural to interpret and comprehend script-like or schematic structures (e.g., Bower & Morrow, 1990; Schank, 1998). Norman (1993) presents stories as being powerful because of their affective dimension. Whereas techniques in logic allow a listener/reader to formulate a "detached, global judgment" (p. 130), techniques in storytelling allow an author to include their personal point of view and to understand – and take advantage of – the emotional influence that their story will have on others (e.g., Linde, 2001).

We suggest that narrative may be powerful tool for supporting certain problem solving elements of macrocognition. Researchers in NDM have long discussed how stories are used in processes such as decision making, planning and sensemaking (see Lipshitz, Klein, & Carroll, 2006). For example, Klein's model of recognition-primed decision (RPD) contains a narrative component in that he describes how experts often engage in systematic story building strategies. In these instances, when it is not readily apparent what solution path should be followed, experts use story in an attempt to overcome ambiguity in the environment. Related to this is the mental simulation where potential actions are imagined to help the problem solver better interpret the situation. Often this form of story building enables a clearer understanding of the extant situations and the nature of the constraints with which the problem solver must deal (Klein, 1998). Within NDM, others have used story and the narrative form to evaluate the quality of organizational learning contexts. Here narrative enables a more precise diagnosis of report quality – that is, the degree to which well written team reports describe causes and provide lessons generalizable across problem solving context (see Carroll, Hatakenaka, & Rudolph, 2006). Similarly, in what are termed explanation based models, one works to generate a coherent story that enables one to deal with an incomplete set of facts. Here the problem solver actively works to fill in gaps and form expectancies such that they can identify potential choices and outcomes (Pennington & Hastie, 1993). Story is more explicitly integrated in NDM models such as Recognition/Metacognition (Cohen, Freeman, & Wolf, 1996) where the problem solvers work in time-stressed environments to develop procedures that help them overcome failures to recognize how to proceed with a given problem. In this theory, teams work to construct and test stories generated from limited data in the environment.

In short, a number of researchers have utilized story for understanding naturalistic decision making process. We support this line of thinking and our goal here is merely to build upon this theorizing by more carefully linking concepts from narratology to problem solving environments. In the final section of this paper we describe a set of the foundational features of narrative to illustrate how they can help us better understand certain problem solving processes as they unfold in naturalistic environments.

NARRATIVE SYSTEMS FOR PROBLEM SOLVING

We emphasize the macrocognitive process of *Developing a Shared Problem Conceptualization*. From the cognitive sciences, this has been said to involve the encoding, representing, and sharing salient aspects of the problem. With respect to this latter aspect, it involves developing overlap between team members' understanding of the essential problem characteristics (e.g. Fiore & Schooler, 2004; Hinsz et al., 1997; Orasanu, 1994). In the present context we suggest this involves the identification of initial problem states, goals, and operators, that is, the actions that change one problem state into another, along with any restrictions on the operators (Newell & Simon, 1972; Hayes, 1989). What is important to recognize is that, following knowledge building activities by the team, individuals within the team use collaborative activities to build a perceptual and conceptual understanding of their problem. This enables the team to create a common ground concerning the problem they are facing which, in turn, supports the development of the team's problem model. The narrative concept is applicable to a number of macrocognitive process and we next discuss how the features of narrative as outlined by Bruner (1991) can be adopted to help understand some of the facets of collaborative problem solving.

Table 1 lists the features of narrative (from Bruner, 1991) most relevant to our discussion. These features can be studied to analyze narrative in a hermeneutic sense, dipping below the surface layer of actions and environment to uncover deeper meanings that may exist in the problem solving context. For example, Bruner speaks of *intentional state entailment* to describe how agents within a narrative have desires or goals which motivate them to move through the various plot points in a story. This is well-suited for problem solving in that problem solving teams must be ever mindful of both the overall team objectives as well as the individual motivating forces that shape activities embedded in particular contexts. Within complex problem solving environments, the narrative actors (perhaps representing team members) all have goals within the parameters of their particular situation. But these intentions are often thwarted in some way such that problem solving does not always proceed as expected (e.g., through faulty data or the actions of others). As such, this component of narrative helps us to interpret why, for example, a distributed team member or even an adversary, behaved as he/she did (see Fiore, Johnston, & McDaniel, in press).

Bruner's notions of *context sensitivity and negotiability* also have interesting connections to macrocognition. Context sensitivity applies individual experiential knowledge to the interpretation of narratives, essentially allowing the narrative and the reader to form an organic relationship within the mind of the individual. Similarly, in problem solving, both the individual knowledge of team members, and the team knowledge collectively, are significantly brought to bear on the problem solving process. This organic knowledge that arises from the embedded activity of the team along with the team's individual and collective knowledge, interact to shape the beginnings of the team problem model. Indeed, this is analogous to the creation of the "situation model" as espoused by researchers such as Kintsch (1988). But Bruner's notion of negotiability pertains to the disparity between narrative truth and individual interpretations or recollections. Both of these features support what literary critics have often called the *reader-response* method of criticism, in which a narrative is thought to be experienced in an idiosyncratic and real-time fashion which cannot be easily studied by outside scholars. Such processes may occur in problem solving contexts via generation of alternative problem interpretations.

Table 1. Features of Narrative (from Bruner, 1991).

Intentional State Entailment	Describes how an actor within a given story has within him/her certain goals or desires that must be attained
Context Sensitivity	Notion of how a reader's background knowledge interacts with the interpretation of the narrative
Negotiability	The separating out of truth from the story, thus allowing for differing explanations of what occurred based upon the idiosyncratic interpretations one may have of what transpired
Referentiality	Term describing how narrative does not refer to reality, rather it creates its own reality
Narrative Diachronicity	Used to describe how events within a narrative occur over time or the particular patterns of events that unfold over time
Canonicity and Breach	Features within a narrative that make a story interesting enough to tell - that is, a break from a predetermined sequence of events (e.g., a script)
Precipitating Event	The factor leading to the breach of the canonical script

Features such as intentional state entailment, context sensitivity, and negotiability strongly illustrate why adding structure to macrocognitive systems is critical. Similarly, Bruner's other features of narrative can be used to study narrative-based problem solving systems. *Referentiality* refers to the emergent meaning-making capacity of narrative: rather than being bound to reality, narratives can – and do, in fact – create their own realities. This is best understood by recognizing that ambiguity always exists in problem solving contexts and that problem representations may not always represent "ground truth". Within the context of integrating narrative into an understanding of problem solving, this is an important issue. The danger is that narrative can have a truth all its own, leading the problem solvers to consider narrative truth from verisimilitude, that is, the *appearance of truth*, rather than through verifiability (Bruner, 1991). Specifically, in order to effectively document the complexity inherent in problem solving contexts, that is, develop an accurate story, we must have an accurate understanding of the reality of the situation. This is based upon the identification of critical events and their consequences. Any resultant story needs to be constructed from these events and based upon the interpretations of the varied team members – this becomes the reality through which solutions are generated (Fiore, Johnston, & McDaniel, 2005).

Temporal elements of narrative are also highly pertinent to supporting problem solving. Bruner describes the temporal sequencing feature of narrative as *narrative diachronicity.* Viewing this within the context of macrocognition, problem solving can be represented as a series of temporally and causally connected events that can be used to help represent the complexity inherent in certain patterns. This temporal sequence supports the narrative system and may highlight or prominently position certain occurrences for interpretation by the team. It is important to differentiate between narrative time and real world time; we do not suggest that teams must follow the story chronology when *reading* the narrative, but only that the internal temporal sequence of the narrative is present and important in its causal structure. In fact, certain benefits may be found in manipulating this temporal sequence in alternate, unplanned directions, such as reversing the plot sequence or accessing plot elements in random order. Depending on the context and the method of capture, of course, storytelling can be a powerful device simply in terms of temporal sequencing and debriefing of activities.

Canonicity and breach describe the tendencies of narratives to follow fundamental structures, or canons, and deviate from those patterns to powerful effect. Bruner (1991) explains why narrative differs from a predetermined sequence of events (e.g., a script), "for [a story] to be worth telling, a tale must be about how an implicit canonical script has been breached" (p. 11). This breach of the canonical script is referred to as a *precipitating event* (Bruner, 1991; Herrnstein-Smith, 1978). Viewing these constructs within problem solving environments, we can use the narrative structure to help us interpret the actions of actors in the story. The *breach* helps us understand why the script did not go as planned, in turn, leading to the problem(s) at hand. As with diachronicity, this underlying concept is used to weave together the critical events that are used to help the team members understand the problem. This then forms the basis for structuring the story used to present to the team for solution generation. Thus, when considering problem solving as an unfolding narrative, and the contents of the situation as a particular *story*, the value of our metaphor can be strengthened. In particular, the breach in the canonical script, that is, the precipitating event, becomes a potential target for solution generation (see also Fiore et al., 2005; in press).

SUMMARY

In sum, the features of narrative as described by Bruner (1991), and elaborated upon here, present an effective means through which we can conceptualize elements of macrocognition and how they might be structured to aid problem solving. Our goal was to provide an illustration of how the pedagogically sound concept of narrative can be integrated with information systems so as to facilitate performance in problem solving environments. Essentially, it is the unfolding of events in complex collaborative problem solving and the interaction of actors within the situation that creates the story that needs to be understood. Narrative can enable this process because it "operates as an instrument of mind in the construction of reality" (p. 6, Bruner, 1991) and in the present case, the reality of what is occurring when teams collaborate to solve problems in macrocognitive environments.

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