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NARRATIVE THEORY AND DISTRIBUTED TRAINING: USING THE NARRATIVE FORM FOR DEBRIEFING DISTRIBUTED SIMULATION-BASED EXERCISES

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In this chapter, we suggest that the narrative form represents a cogent means with which to describe and help comprehend complex training events. We discuss the value of narrative within distributed training environments and how it represents an important and little-understood research issue that can support a science of learning for complex organizational entities interacting at a distance. As our focus, we describe narratives in the context of distributed simulation-based exercises, the means through which teams

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of teams in the military practice complex tactics serving some strategic goal. Our overall theme is predicated on the notion that through the use of the narrative form, learning content can be both more effectively conveyed and more memorable.

This chapter is a continuation of prior work that attempts to rely on sound psychological theory to develop techniques and technologies that can be used to provide an organizing structure for distributed training environments (Fiore, Salas, Cuevas, & Bowers, 2003). This line of inquiry argues that for complex training content to be appropriately processed, and lead to knowledge acquisition and integration, its presentation needs to be more effectively managed. Furthermore, it recognizes that content can be processed not only during actual training execution but also at other stages of learning (see Cannon-Bowers, Rhodenizer, Salas, & Bowers, 1998; Smith-Jentsch, Zeisig, Acton, & McPherson, 1998). Fiore and colleagues have built on these ideas to argue for a firmer understanding of how to develop training by means of approaches that integrate preprocess, in-process, and postprocess factors (Fiore et al., 2003). Their approach illustrates the potential for improvements in knowledge construction based on a principled approach to distributed training design across time. These labels of *pre-*, *in-*, and *postprocess* factors correspond to notions of preparation, execution, and reflection, respectively (see Fiore, Jentsch, Becerra-Fernandez, Salas, & Finkelstein, 2005). Specifically, whereas in-process action (i.e., execution) occurs during actual training, preprocess actions (i.e., preparation) involve preparatory pretask behaviors. These include preparatory behaviors, such as planning sessions (e.g., Cannon-Bowers et al., 1998), or the use of mobile learning technologies to ground upcoming content in some pertinent context (cf. Metcalf, 2006), or pretask briefings where initial expectations are created in anticipation of the interaction (cf. Fiore, Salas, & Cannon-Bowers, 2001). Similarly, postprocess actions (i.e., reflection) include posttask feedback delivery and rumination on performance (e.g., debriefing) where task feedback is administered to individuals and groups by means of after-action review technologies (e.g., Fiore, Johnston, & McDaniel, 2005; Knerr, Lampton, Martin, Washburn, & Cope, 2002). Such antecedent (e.g., Cannon-Bowers et al., 1998; Wittenbaum, Vaughan, & Stasser, 1998) and consequent (e.g., Smith-Jentsch et al., 1998) behaviors can be critical to successful knowledge acquisition when conceptualized within a training paradigm that views learning across time.

Within the context of distributed debriefing, Fiore, Johnston, and Van Duyne (2004) presented a conceptualization of a training space to argue that events within such a space need to be woven together to enable the learner to experientially and cognitively link training concepts (see also Fiore et al., 2005). By integrating memory theory and organizational processes in human memory with techniques to diagnose and debrief performance, Fiore et al. (2004) illustrated how events within the training space can be monitored, filtered, and potentially structured such that they become interconnected across pre-, in-, and postprocess interaction. In this way, performance feedback could be idiosyncratically tailored and integrated within a larger conceptual organization of the overall training mission.

In this prior work, endogenous processes associated with the learner (e.g., organization in memory) were integrated with the exogenous factors associated with the learning environment (e.g., training requirements). Specifically, Fiore et al. (2004) discussed how theories originating in cognitive psychology provide an effective means by which to conceptualize the organization and the presentation of feedback to maximize the implementation of team feedback. This theory was based on a long line of research in human memory documenting the natural tendency for categorization to benefit memory (e.g., Bousfield, 1953; Bower, Clark, Lesgold, & Winzenz, 1969; Mandler, 1967). Fiore et al. (2004) argued that findings on memory hierarchies can be used to develop principled methods for automating the diagnosis of performance and the presentation of feedback during distributed mission training. By deriving hierarchies from the training requirements, a particular form of representation could be developed such that it presented a representation of team members and their actions at a given point in time (e.g., good and poor performance). This representation is necessarily hierarchical in nature, and this inherent organization in distributed teams of teams was leveraged to provide a strong mnemonic that would be robust in the face of competing content.

In short, our prior efforts in this area suggest that an appropriate blend of learning and system factors can assist in developing targeted feedback methods and mechanisms during postprocess interaction (see also Fiore et al., 2003, 2005). In this chapter, we build on this approach to additionally consider how the sequentiality inherent in distributed training can be leveraged. Specifically, our hierarchical consideration of the training space (Fiore et al., 2004) was developed to allow presentation of performance at a given point in time, that is, a "slice in time" of a complex mission, rather than across a time period. Here we continue with the development of theoretical concepts to enable an understanding of how distributed training environments can be efficaciously parsed and presented to maximize learning and retention. We do this from the perspective of narratology, building on our recent discussions of the use of narrative as a learning and performance support tool (see Fiore & McDaniel, 2006; Fiore et al., 2005; Fiore, Metcalf, & McDaniel, 2007). We next provide a brief overview of the different disciplines that have used the narrative form as a means of information conveyance. After this, we discuss some of the primary features of narrative that have been identified as being integral to the narrative form. Finally, we discuss these theoretical approaches in the context of using them for debriefing distributed simulation-based exercises.

THE NARRATIVE FORM IN COGNITION AND LEARNING

In his influential work on narrative, Bruner (1991) described how we come to know our world and construct our representation of reality through the use of narrative. Bruner argued that "we organize our experience and our memory of human happenings mainly in the form of narrative—stories, excuses, myths, reasons for doing or not doing, and so on" (p. 4). Storytelling and the narrative format are argued to be some of the earliest means with which knowledge was retained and passed from generation to generation (e.g., Bal, 1997; Denning, 2001; Snowden, 2001). The utility of story to encompass a number of not only cognitive factors but also attitudinal issues is perhaps one of its strongest points. Indeed, Donald Norman (1993) wrote that "stories are important cognitive events, for they encapsulate, into one compact package, information, knowledge, context, and emotion" (p. 129).

At this more finely grained level of analysis from the viewpoint of cognitive psychology, a long line of research suggests that humans are predisposed to follow scriptlike or schematic structures (e.g., Bartlett, 1932; Bower & Morrow, 1990; Bransford & Franks, 1971; Gagne & Glaser, 1987; Mandler, 1984; Rumelhart, 1980; Schank & Abelson, 1977; Trabasso & Sperry, 1985). Indeed, a number of complex cognitive processes are engaged when one comprehends a story in that "the enabling events and causes form a web of connections among other events and conditions" (Bower & Morrow, 1990, p. 45). Furthermore, a substantial body of research has examined how brain injury hinders one's understanding of narrative. Importantly, illustrating how this ability is strongly linked to cognition, these studies have shown how this deficit can be related to a number of other higher cognitive functions, such as planning and social interaction (Body & Perkins, 1998; Bond-Chapman, Levin, Matejka, Harward, & Kufera, 1995; Chapman et al., 1992; Coelho, Liles, & Duffy, 1995; Togher & Handoe, 1999). Others have used studies of patients with closed-head injuries to illustrate how examination of narrative skills (e.g., discourse generation) can be clinically diagnostic. For example, patients with closed-head injuries are less able to produce cohesive ties across their utterances (Hartley & Jensen, 1991). Such techniques have also been used in developmental studies comparing young children with perinatal brain injury and healthy age-matched control children. Across these groups, the children with brain injuries were less able to integrate their play narrative and were less able to distinguish across types of narratives. Finally, there were significant developmental changes in the normal control children, illustrating how narrative skills develop with maturation (see Hemphill et al., 1994, for a full discussion). As this brief review suggests, a substantial foundation of research exists linking narrative to essential information processing, and this comes from both behaviorally and neurologically based studies. These studies provide a strong body of evidence indicating that the narrative form is a fundamental subcomponent of human cognition.

Some researchers, leveraging off this strong body of extant literature on narrative, have expanded on it to illustrate how to use story as a tool for learning. For example, Schank (1998) argued that human interaction can be better managed through the use of narrative and that the more effective means of reaching someone (whether a customer or a peer) is through stories. Schank argued from a cognitive perspective, suggesting that stories are able to scaffold another's understanding through the conveyance of context, that is, contextual elements facilitating relational thinking involving the incoming information and what one already knows. It is interesting that this same system may allow for temporary suspension of one's normal script or framelike patterns of thinking to allow for a more unconscious type of learning and engagement. Specifically, some researchers have noted that while engaged in listening to, or even telling a story, "our habitual mental sets, common everyday frames of reference, and belief systems are more or less interrupted and suspended" (Abrahamson, 1998, p. 442). Thus, curiously, it is the power of story that lets us suspend our own personal narratives to be engaged by, and potentially learn from, a story.

In a more qualitative analysis of storytelling, Sturm (1999) similarly noted this suspension of our everyday belief systems. Relying on interviewing techniques administered during professional storytelling events, Sturm examined the relationship between storytellers and story-listeners and found that participants in these events experienced "qualitatively different" states of consciousness while listening to various narratives as delivered by seasoned storytellers (p. 6). On the basis of analyses of the interview transcripts, Sturm outlined six categories that described this suspension of normal alertness. These categories included (a) feelings of realism for the story and story characters; (b) a lack of awareness for current surroundings or the current environment; (c) engaged receptive channels (visual, auditory, kinesthetic, and emotional); (d) feelings of control as either being in control of the direction of the story or being helpless; (e) a sense of "placeness," or the feeling as though they were being transported into another space; and (f) time distortion (p. 7). When received in this purely visceral or semi-hypnotic mental state, stories may have the means to elicit affective responses that make conceptual information more meaningful and, perhaps by extension, more transferable from long-term to short-term working memory. From this more visceral or base level, some have researched how storytelling can be used to elicit emotional responses in simulated and mixed-reality environments (Stapleton & Hughes, 2003). This line of inquiry has been built on a collaboration between the computational sciences and digital media, with the goal being an integration of story and entertainment with simulation technologies (Hughes, Konttinen, & Pattanaik, 2004; Stapleton, Hughes, Moshell, Micikevicius, & Altman, 2002). From this theoretical and technological integration, these researchers are exploring how story-driven simulations may enable learning for a variety of domains. For example, Stapleton and colleagues are investigating techniques to teach language skills to children with communicative disorders.

Stories often leave certain connections or causal relationships ambiguous; it is up to the reader to make definitive connections between particular events and characters. The characteristics of uncertainty and incompleteness are also useful components of story for narratives used in learning environments. This responsibility on the part of the reader is often precisely what is needed to give educational material a degree of importance, or even novelty. In particular, some suggest that when stories incorporate uncertainties, readers or listeners engage in imaginative gap-filling by drawing on personal experiences. This in turn may produce a sense of emotional or intellectual attachment to the story (see Gershon & Page, 2001). Gerrig and Egidi (2003) mirrored this sentiment: "Narratives refer to a small selection of details and let readers complete their work by imagining the rest. The resulting discontinuity that characterizes narrative requires an active role on the part of the reader" (p. 36). If one views this concept through cognitive theory, one can see that this process essentially increases the requirements for elaboration and is analogous to memory research showing that manipulations that force the elaboration of the to-be-learned material (e.g., semantic judgments) increase retention. This is also similar to work in self-explanation, which shows how the learner benefits from elaborating on the to-be-learned material (e.g., Anderson & Schunn, 2000; Chi, 2000). In this research, when the learner is encouraged or prompted to self-generate conceptual elaborations, monitoring and comprehension are facilitated, as is knowledge acquisition (e.g., Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Chi, de Leeuw, Chiu, & Lavancher, 1994; King, 1992; Rosenshine, Meister, & Chapman, 1996). On the basis of this theorizing, we suggest that the active information processing on the part of readers as they engage in their personal gap-filling may increase the memorability of the read material. Furthermore, this personalization and contextualization of material may help to build the type of critical thinking skills that are essential for intellectual development.

In terms of specific pedagogical applications, storytelling has long been suggested as a valuable tool for classroom learning. Many of the advantages

of story are well suited to teaching and teaching strategies. For instance, narrative has been theorized as being advantageous for memory recall and accessibility (Abbott, 2003), domain-independent types of thinking and the understanding of spatiotemporal relationships (Herman, 2003), and emergent types of learning (Turner, 2003). The power of stories, when used as potential teaching tools, has not gone unnoticed. Mathison and Gallego (2002) wrote that many educators routinely take advantage of stories in various forms (e.g., anecdotes, folk tales, oral histories, or biographies) to help their students understand concepts and ideas from their teaching. Crafting and delivering a good story can often move a student from a state of passive listening and boredom to an active state of engagement with the subject matter. This process can actually contribute to an improvement in the teacher's knowledge of subject matter as well. As Mathison and Gallego explained,

> The creator of a good story has had to reflect on the order, meaning, priority, and usefulness of the events she or he weaves together. So, by its very nature, the process of good story formation involves critical and reflective thinking. (p. 2)

This reciprocal generosity of narrative pedagogy is a definite advantage that comes from the process of incorporating stories into normal classroom activities. Along these lines, research has linked story, technology, and live performance in educational and training environments (Hirumi, Knowland, & Pounds, 2004). These studies have examined how the blending of disciplines can be used to educate teachers in complex content areas, such as computer operations (Mckenna, Pounds, & Hirumi, 2004).

Storytelling practices have also proven beneficial when used as tools for literacy learning for young children. For example, research with intelligent-agent technology has shown how stories can aid in the development of more complex reading skills. Ryokai, Vaucelle, and Cassell (2003) developed an embodied storytelling agent, named Sam, who was projected onto a screen behind a toy castle and figurine. Sam would then tell one or two children stories about the castle and figurine that were designed to model complex linguistic elements such as decontextualized language, quoted speech, spatial expressions, and relative clauses. One important facet of this project was that after a certain amount of time had passed, Sam's stories would become less interesting to the children, and these children would then be compelled to correct Sam by reciting appropriately exciting stories back to the agent. By doing so, Ryokai et al. found that "children practiced ways of clearly presenting narrative ideas for an audience, which is one of the keys to literacy learning" (p. 206).

As this brief review suggests, narrative is an important component of cognition, and its use cuts across the educational spectrum that has been explored with children and adults. Indeed, as Herman (2003) described it, the narrative form is a

> powerful and basic tool for thinking, enabling users of stories to produce and interpret literary texts, carry out spontaneous conversations, make sense of news reports in a variety of media, create and assess medical case histories, and provide testimony in court. (p. 163)

The power of story to express complicated or multifarious ideas is thus revealed in its track record in genres ranging from entertainment to law to politics. Complex thought as expressed in stories is manifested in everything from normal day-to-day conversations to complex descriptions of technical processes or procedures. We turn next to a discussion of how these ideas have been incorporated into technologies that leverage this concept to enable a host of complex automated processes.

COMPUTATIONAL STRUCTURES FOR NARRATIVE

Interesting dynamics are found when storytelling is combined with technology. In particular, narrative has influenced certain areas of research and development in computer science. For example, in areas such as interface design, researchers in human–computer interaction have argued that a metaphor of oral storytelling can be used to organize knowledge bases by incorporating concepts such as storylines and events unfolding over time (Berg, 2000; Don, 1990). Others have viewed narrative in computational systems, not metaphorically but almost literally. Specifically, a *narrative system* is a computer-based technology that is designed according to the way the cognitive sciences suggest we mentally store and categorize information. Both Minsky (1985) and Schank (1998) have developed the concepts—frames and scripts, respectively—to leverage narrative to help explain comprehension processes.

In computer science research, the concept of narrative has been adopted to make computer systems more understandable by developing techniques that facilitate communication in ways that mimic narrative (Mateas & Sengers, 1999). For example, narrative has been pursued within the emerging discipline of texts and technology to examine story and the narrative form in the context of knowledge management within organizations. The goal is to develop artificial intelligence applications using concepts such as narrative information exchange to support organizational memory and learning by capturing experiences in ways that people actually use to make sense of complex events, that is, as experiences conveyed through stories (see McDaniel, 2004).

An additional technique for integrating narrative communication into computers is to adapt the frame model to work within a digitized environment. Minsky (1985) explained that frames can be construed as experience-based structures of knowledge (p. 244). Specifically, he argued that each person acquired a tremendous number of frames, with each differently representing a type of stereotypical situation (e.g., meeting a certain kind of person). He described the structure of the frame as "a sort of skeleton, somewhat like an application form with many blanks or slots to be filled" (p. 245). These blanks inside a person's frame are "terminals" that are used "as connection points to which we can attach other types of information" (Minsky, 1985, p. 245). A frame can therefore be thought of as a template for creating specialized instances of a general idea, or a template for mnemonic abstraction. Story frames, then, are general templates for creating specialized instantiations of stories (Minsky, 1985). For example, from a general story frame it is possible to model a fairy tale, an adventure story, a historical narrative, or a tragic romance.

Just as Minsky's (1985) frames construct can be used to encapsulate digital stories after they have been created, Schank's (1998) ideas about scripts can be used to elicit appropriate stories and shape them into their final forms. Schank defined a *script* as "a set of expectations about what will happen next in a well-understood situation" (1990, p. 7). Scripts are useful in that they map a set of social or cultural conventions into a particular setting, so that when a new setting of that type is encountered the conventions for interacting within that setting are already known. When using scripts to design or control narrative systems, the computer can be programmed to understand normal or abnormal developments that occur within a story situated in a particular environment.

From this perspective of developing computationally robust narrative systems, frames are readily adaptable to technology-based approaches because they are very similar to a computational methodology already in widespread use: the object-oriented programming (OOP) paradigm. In most OOP models a class is first created to specify how objects should be assembled. The class thus acts as a template for one or more objects to be created from, much like a set of blueprints describing how a building should be constructed. From a single class, multiple objects can be produced that contain properties (internal data reflecting the current state of each object) and methods (internal procedures that describe the current allowable behaviors for each object). When dealing with narrative objects, these state properties will be composed of critical story elements, such as times, locations, characters, and events. Behaviors will then be composed of procedures that allow entry into various points in the narrative or that otherwise return meaningful data related to a particular occurrence in a given story.

For a computer language to be considered object oriented, that language must support four properties: (a) abstraction, (b) encapsulation, (c) polymorphism, and (d) inheritance. Like objects used in OOP languages, narrative frames seem to support these same OOP features on a cognitive level. For instance, both the OOP paradigm and the story frame construct support *abstraction*, or the ability to represent complex world data and relationships using abstract constructs (objects or frames). Additionally, frames and objects both encapsulate this abstract material within the boundaries of the frame or the object. Although a story can be blended or combined with another story to create an emergent narrative, the original features of the reactant stories remain encapsulated within their original frameworks.

The next property of OOP languages, although slightly more difficult to define, is still relevant to narrative systems. Polymorphism in OOP is allowing the same code to be used to process different types of data. Another way to think of polymorphism is as the "customized interpretation of a message" and the resulting use of that interpretation by different types of objects (Brookshear, 2000, p. 267). For instance, there might be a Turn_Page method that works with both Book and Newspaper types of objects. The particular implementation of the Turn_Page method needs to be different depending on the type of object that is using that function; the mechanics for each operation are slightly different, which is of course due to the differences in composition of each object.[1] In other words, finding the next page in a newspaper article is often much more convoluted than finding the next page in a cover-bound novel. In a newspaper, this process often involves rotating and folding the newspaper to situate the appropriate continued section into a readable arrangement. With a book, though, turning a page is accomplished simply by moving one's eyes to the next adjacent page or by flipping over the adjacent page to read the back of a page and open up the next two-page segment. The procedure for accessing this functionality, however, remains the same for each object: Book.Turn_Page or Magazine.Turn_Page. Dot notation, or providing a period after each object's name, allows a programmer to fully qualify a method using an object's name and the particular method encapsulated within that object. Although both methods to turn to a new page are named exactly the same in both the book and the magazine objects, the use of dot notation removes ambiguity from any given request to access an object's Turn_Page method.

Thus, polymorphism ensures that although the deep structure of the functionality—that is, its underlying purpose—is similar, its surface structure may vary depending on the nature of the content (object). In a narrative frame, the same polymorphic requirements can and should be met. For instance, it might be useful to have instant access to the complicating section of a given narrative, or that point in the narrative in which dramatic action is at its peak. Although the events leading up to this section and the outcomes after these complicating events would likely be very different, one can still access the complication part of a story in the same fashion for two very different types of stories (assuming they both contained complicating events). Dot notation can then be used to call forth these complicating events in a consistent and programmatic fashion by an analyst (i.e., Story1.Get_Complication, Story2.Get_Complication, etc.).

The last property of OOP, *inheritance*, also relates to the narrative frame construct. In programmed inheritance, child objects can inherit property data and functionality from parent objects that exist somewhere higher in the object hierarchy, much like inherited traits found in human genetics. The term property describes an object's data structures and the values assigned to those data structures. Functionality is defined in terms of encapsulated object methods that can provide access to internal data structures or otherwise modify these structures in a meaningful fashion.

For example, in a given simulation it might be useful to model the weather for an environment. In this environment there would be several types of clouds that would have associated probabilities for outcomes, such as rain or extreme temperatures occurring within the simulation. These clouds would be instantiated from a base Cloud object that would have properties defining its characteristics with properties for size, density, rain probability, and location, and perhaps a method Rain for creating virtual rain. In this base object, then, a programmer would assign a number representing the probability that rain will fall from that cloud. In its default state, this probability could be set to .20 using the value associated with the Cloud.RainProbability property. To run this situation in a rainy environment, the programmer might then wish to create a group of clouds composed of two or more RainCloud objects that have a much higher probability of dropping rain on the earth. Instead of modeling each individual RainCloud as a new object, it would make more sense to have these new objects inherit from the initial Cloud object and extend its functionality by adjusting its default property values and perhaps adding new methods, such as RainCloud.DownPour. If a normal rainy day were required, then the parent's Rain method could also be called by accessing the RainCloud.Rain method inherited from the original Cloud object. Thus, the rain probability for RainCloud objects can be adjusted to .80 so that all new objects created from this class template will have an 80% chance of spawning virtual rain.

This ability to inherit and extend allows customization of generic objects into instance-specific models that inherit base functionality and extend this new object's capabilities in additional directions. Using narrative

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[1] Virtual "objects" discussed in this section are capitalized for clarity, as is often the convention in programming.

objects, inheritance can therefore be programmed into a narrative system. First, a collection of base stories are created that contain terminals for the main character in the story, the significant events in the story, and the time and location in which the story took place. A secondary collection of stories would then inherit these base terminals and add additional terminals specifying whether the story took place in a simulated environment or a real world environment. Each inherited narrative frame could then spawn an unlimited number of stories about simulated and real world stories, depending on the type of narrative frame from which they were created.

The similarity of narrative frames to OOP constructs makes them very easy to implement using computational languages since frames translate easily to objects. In this type of model, a frame is represented using a class template, which is a pattern that allows new story objects to be created at will. From a class template, many objects can be created that have the same placeholders (terminals) but with different data stored in these locations. In the next section, we integrate the aforementioned theoretical concepts through the use of Bruner's (1991) essential features of narrative. We do this through a focus on a complex applied training problem in use today: Distributed Simulation-Based Exercises (DSBE). Our goal is to show how these important theoretical developments on story and narrative systems can be realized in a real world training environment, illustrating how a science of learning in distributed environments can be pursued on both epistemological and ecological grounds.

MERGING NARRATIVE SYSTEMS WITH DISTRIBUTED TRAINING ENVIRONMENTS

Distributed simulation-based training is one of the most challenging and resource-intensive training efforts facing the Navy—within services, joint service, and in a coalition with foreign military services. It is extremely personnel and resource intensive, requiring many hours (e.g., role players, trainers, simulation operators, travel funds) to support the implementation of training in high-fidelity simulations. Such a complex training environment is necessary because of the increasing complexity of military operations. Furthermore, there is a recognized need to allow trainees practice in integrating the skills they have acquired with others such that they are able to begin coordinating these skills.

Here we discuss training in the use of DSBEs and illustrate how the narrative form can be seamlessly blended with these complex training environments. In business, for example, narrative has been described as a viable tool for improving organizational communication and facilitating project management across groups (Denning, 2001, 2004; Snowden, 2001). Our specific goal is to highlight the potential value of this construct for the purpose of devising debriefing technologies that are more efficacious for the learner. As the previous review suggests, the narrative concept is applicable to a number of issues cutting across the social and information sciences. Considering the narrative form as just described, along with how the information and computational sciences have been using this construct to design narrative systems, we discuss narrative in the context of the features of narrative as outlined by Bruner (1991). We do this to begin to form the foundation for how it is that narrative systems for DSBEs can be developed. Specifically, within the context of distributed simulations, we suggest that the *story* is what actually happened in a given simulation-based training exercise, but *narrative* can better explain the complexity inherent to this story. At this point, it is important to specify how our interpretation of narrative within the context of training can be distinguished from conceptually similar theorizing, that is, scenario-based training. Scenario-based training has relied on vignettes that are devised to be analogous to actual experiences and environments but that include articulated learning objectives to elicit the use of particular competencies (e.g., Cannon-Bowers et al., 1998; Dwyer, Oser, & Salas, 1998; Dwyer, Oser, Salas, & Fowlkes, 1999; Fowlkes, Lane, Salas, Franz, & Oser, 1994). We do not necessarily see our approach with narrative as being at odds with this. Specifically, the scenarios are themselves constructed around a priori stories created by subject-matter experts and training designers. We suggest that the narrative form be used to convey what actually transpired during simulations, regardless of whether those simulations have been derived from scenario-based training.

In addition to considering the properties of narrative conducive to debriefing applications, we also provide examples of how stories can be used in electronic environments to manipulate simulation and debriefing data using data structures. Following the core capabilities found in many modern programming languages, we chose to consider how narratives can be wrapped around debriefing reports in an object-oriented fashion, thus taking advantage of the four properties of (a) abstraction, (b) encapsulation, (c) polymorphism, and (d) inheritance to store and manipulate debriefing information in narrative form. The function of abstraction is fairly obvious for each feature; the ability to model narratives in any computational form depends on this ability to represent real-world agents and actions in an abstract state. The other three properties, though, can have interesting implications for narrative debriefing. As such, we expand these three additional properties for several of the significant characteristics and features of story.

The features of narrative (from Bruner, 1991) most relevant to our discussion are listed in Table 6.1. Certain components of these features pertain to fiction and the way one uses these features to provide the sense of realism a reader–listener finds so compelling. For example, Bruner wrote

TABLE 6.1
Features of Narrative

Narrative diachronicity	Used to describe how events within a narrative occur over time or the particular patterns of events that unfold over time.
Intentional state entailment	Describes how an actor within a given story has within him or her certain goals or desires that must be attained.
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.
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 on the idiosyncratic interpretations one may have of what transpired.
Referentiality	Term describing how narrative does not refer to reality; instead, it creates its own reality.

Note. From "The Narrative Construction of Reality," by J. Bruner, 1991, *Critical Inquiry, 18,* pp. 1–21. Copyright 1991 by *Critical Inquiry.* Adapted with permission.

of *referentiality* to describe how narrative does not refer to reality but instead creates its own reality. Although on the surface this may not seem to pertain to DSBE, one could argue that the training community must be ever mindful that it can sometimes create reality rather than represent reality. This is best understood by recognizing that military trainers speak of "ground truth" to describe what actually happened and in recognition that one's interpretation of what happened may deviate from this truth. Within the context of integrating narratology into DSBE debriefing, this is an important issue. Specifically, to effectively diagnose the simulation–story—that is, to correctly interpret what transpired to determine who did what well, and who did what poorly—one must have an accurate understanding of the reality of the situation. This is based on the identification of critical events and their consequences. The resultant story, which is constructed from these critical events and based on the interpretations of the trainers, the diagnoses systems, and techniques they have devised, becomes the reality through which performance is evaluated.

Context Sensitivity and Negotiability

Context sensitivity and *negotiability* are as much philosophical constructs as they are practical necessities. Although context sensitivity, when used in discussions of narrative, easily conveys notions of how the reader's background knowledge interacts with the interpretation of the narrative, Bruner's (1991) notion of negotiability pertains to the separating out of truth from the story. This allows for differing explanations of what occurred based on the idiosyncratic interpretations one may have of what transpired. This does occur at least analogously in what are referred to as *alibis*, which sometimes are offered in unstructured debriefs. In particular, during debriefing team members may generate plausibly sounding yet questionably true excuses for why something went wrong. Referring to our earlier discussion of ground truth, in the absence of an objective evaluation and presentation system, alibis may succeed simply because members of a given team are better able to negotiate their own interpretation of precipitating events and what transpired after these events.

We began with these two features of narrative, that is, referentiality and negotiability, because they strongly illustrate why adding structure to debriefing systems is critical. Along these lines, in the remainder of this section we describe how Bruner's (1991) other features of narrative can be used to create the level of objectivity necessary to efficaciously devise debriefing using narrative. Specifically, we describe the critical features of narrative that can be woven into debriefing, and we describe how computerized narrative systems can help to objectify these data for presentation.

Narrative Diachronicity

The feature of narrative that is perhaps most pertinent to DSBE, and certainly the most foundational feature, has to do with time and the laying out of events in a sequential form, which Bruner (1991) labeled *narrative diachronicity*. Viewing this within the context of DSBE, each simulation unfolds as a particular pattern of events, and we suggest using a story during the debrief to explain this pattern. This story chronology forms the backbone for the narrative system and enables particular elements to be structured for the debrief. We do not mean to suggest that the debrief must follow the story chronology, only that the narrative component of the chronology is implicitly present.

From an object-oriented perspective, narrative diachronicity is a critical feature. To read or listen to a story that is encapsulated within an object, one needs some meaningful way of relating the events that are stored within that object. In other words, if events within a story are returned in a scrambled and nonsequential fashion, the meaning and importance (and perhaps even the logical structure) of the story are lost. Narrative diachronicity must therefore be maintained and uninterrupted when debriefings are converted into an object-oriented electronic format.

Polymorphic characteristics resulting from narrative diachronicity might also be present in story objects. For instance, two stories generated from story frames can each have the same basic transition of events: An unknown situation is encountered, a struggle ensues as the best course of action to address this situation is decided on, and then an outcome is reached based on the final event in the story. If the unknown situation and the final outcome of these stories are the same, but the action taken to reach these similar outcomes is different in each story, then this narrative system can be described as *polymorphic*. Although these stories have the same plot structure, the particular implementation of each action item, although it generates the same end result in its respective story, is different.

In addition to encapsulation and polymorphism, inheritance is a useful feature to enable when considering narrative diachronicity. The ability to inherit a base story's events and add new events may be useful for training purposes. For example, teams of teams interacting within a DSBE have similar and different components of their mission. What makes inheritance a particularly useful notion is that narrative systems can be used to leverage the similarities within a mission but across teams and build the debrief around them. The noninherited components, then, become the idiosyncratic elements of the debrief that pertain to a particular team or team member. Thus, instead of having each team member tell a story that begins and ends in identical fashion, a generic story template or story class can be fashioned that contains similar items (e.g., a central beginning and ending). This custom template thus describes, in common language, the events representing the team's experience during a particular scenario. To operationalize this, each team member could use personalized programs that inherit from these base templates and add functionality that enables the team members to populate the story with relevant data from their own performance within the simulation until the terminal event is reached. In this fashion, object inheritance can be useful for modeling narrative diachronicity within debriefing narratives.

Intentional State Entailment

Intentional state entailment describes the factor whereby an actor within a given story has within him or her certain goals or desires that must be attained. When reading, the reader of a story uses his or her understanding of these intentions to interpret the actions of the actors in a story. Within DSBE the actors, that is, team members, all have intentions within the context of their particular missions. However, these intentions are often thwarted in some way such that mission plans do not always proceed as expected (e.g., through error or the actions of others). As such, this component of narrative helps us to interpret why one behaved as he or she did, that is, why a particular mission parameter that fell within the goals of a team or team member was or was not met.

This feature is also interesting to observe in an electronic environment populated by stories that are represented as objects. Because the encapsulation requirement for object-oriented languages ensures that data and the methods available to manipulate that data remain within the virtual boundaries of each story object, the digitized story can be treated as though it is being observed through a screen with varying levels of transparency. At the minimum level of transparency, the story functions as a black box: The beginning of the story is evident by the characters or agents going into a particular scenario and the end of the story is shown through the existence of some final event and the explanation of a final outcome for the story. The inner workings of the object, though, remain hidden to the listener or the reader. This inner functionality is made up of the various connections between internal plot events within the story. At the maximum level of transparency, the beginning and end of the story are still revealed, along with the inner events that take place in between the introduction and the conclusion of the narrative.

Varying the level of transparent encapsulation as just described can be useful for training pedagogy in that this technique could support attempts to predict which actions generate which types of outcomes for a given simulation exercise. The material for the exercise can be collected from the various narratives written and modeled as objects during the debriefing session. This can be used either as a form for querying predictions of performance or in a more directive lecture fashion. With respect to the former, team members can be queried during debriefs to elicit from them their predictions as to the events driving consequential actions within the scenario. After this, the level of transparency can be increased, thereby revealing whether the user predicted the correct events to generate that particular outcome for a given training scenario. Alternatively, with respect to the latter, the transparency within the scenario can be maximized so these are more readily apparent from the onset; that is, the debriefing leader can choose to more immediately highlight critical events. The decision as to what format to use can be based on practical considerations (e.g., time allotted to debrief) or pedagogically determined (e.g., where in their training the team may be).

Polymorphism can also be a cooperative property for digitized stories used in training situations. Polymorphic features allow for standardized access into key events in a narrative that are relevant to intentional state entailment. Data outlining the mission's objectives will initially be available to provide an outside source for facts that determine what objective should have been met or which action should have been taken for a given team or team member. When one of these objectives is not met, polymorphic searches can be used to determine the particular event or sequence of events in which a team member or an entire team deviated from normal mission goals. Although different story objects may be associated with different debriefing events, polymorphism allows for syntactic regularity when passing messages to any of these individualized data structures. Although the implementation of the search will vary depending on the specific structure of the story being searched, the commands to perform any given search will remain the same, regardless of the story's features or composition.

This polymorphic feature is particularly useful for the analysis of debriefing stories, especially when evaluating the emergent event sequences within these stories. Although each team member may have a different and specific task to perform (representing the causal event sequence, or plot, for that team member's story), polymorphic functionality enables the person analyzing the narrative debriefs to access each possible point of plot departure using common nomenclature. This may also function to divide larger stories into separate units of analysis. For instance, in a single mission each team member might contribute to this larger story with his or her individual experiences made up of a beginning event, a series of intermediate events, and a final event. When any team member is given an individual function within that mission, it can be assigned a label of *Mission* by the script that is used when that team member tells his or her story. When looking for data to indicate why an entire team did not behave as expected, then, an analyst could simply cycle through each story looking for the parts of the narrative that describe these individual missions (again, these substories would be searched in a common fashion because of polymorphic message passing). These missions are in essence treated as mininarratives that begin at the starting event of each Mission event and end at the terminating event during which this personalized objective was completed. Although the details of each particular team member will vary according to that team member's personalized mission roles or goals, polymorphism allows one to access these various series of events, or mininarratives, using a common mode of object dot notation and a standardized naming practice for internal narrative threads. Thus, if the entire team's story were represented in an object named TeamMission, and there were three team members, each with their own embedded stories within that larger narrative, then the mission description for both the group and each team member within the group could be accessed using the same syntax (TeamMission.Mission would return the overall team objective or objectives, whereas TeamMission.TeamMemberA.Mission through TeamMission.TeamMemberC.Mission would return individual team member objectives).

Narrative inheritance can similarly be useful to evaluate the level of discrepancy between optimal team projected performance and actual team performance in a simulated environment. A base story can be used as a

foundational narrative from which other narratives inherit basic characters and events. The base narrative, in this context, is structured to contain the normal goals or actions performed by actors in a particular story, that is, the teams and team members for a given scenario. If performance diagnosis presented during the debriefing shows that the team's stories do not correlate with the ideal narrative for the scenario, then this ideal from the base narrative is used for comparison. This process involves looking at the differences between the ideal narrative(s) and the actual debriefed narrative(s) to analyze differences in team process and performance. Furthermore, from a training scenario development perspective, when a revised or updated scenario is created, a base story can be inherited and a new ideal narrative formed with the same base expectations for actor performance and outcomes as shown by the foundational story. This facilitates flexibility in the creation of varied scenarios by providing an underlying template for use in performance diagnosis and feedback delivery.

Canonicity and Breach

Canonicity and *breach* are the features within a narrative that make a story interesting enough to tell in the first place. Bruner (1991) used this notion to explain 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 DSBE, the simulation itself is a scripted event that has within it a set of actors who interact with each other and their machines to meet some goal. Viewing this within the lens of narrative, we can use the narrative structure to help interpret why an actor in the story behaved as he or she did. Within the terms of narrative, we can use the notion of breach to help us understand how the script did not go as planned. As with diachronicity, this underlying concept is used to weave together the critical events that are used during a debrief. This then forms the basis for structuring the story used to present the feedback data. Thus, when considering distributed simulation exercises as an unfolding narrative, and the contents of a given simulation 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 the target of feedback.

Because objects require some degree of encapsulation of data by definition, the narrative feature of canonicity and breach therefore requires special consideration in this context. When creating a story frame for modeling a story, and when crafting a story script for soliciting an appropriately formed story, the designer of a narrative software system must take into account that the power of narrative often emerges as the result of a break in the reader's or listener's expectations. As a result, the script used to gather stories should not be so restrictive as to inhibit users from making creative connections between seemingly irrelevant details and the specific milestones related to mission objectives, but the script should not be so permissive as to allow users to overlook important events or to allow them to alter order of occurrences. Debrief stories from a DSBE, then, should be modeled around a core set of events and, subsequently, breaches of events, with a common library of potential characters, but they should also allow for the encoding of special variations in the debriefed narrative. Specifically, given the complexity of distributed simulations, it is not feasible to present the entire mission (i.e., revisit the entire story) during the debrief. As such, the choice needs to be not only objectively determined (i.e., performance data must be gathered to identify the weak areas) but also subjectively determined (i.e., the debriefing leader identifies the element to discuss). This aforementioned liberty would allow a debriefing leader to determine the particular elements of the simulation that are noteworthy, that is, to choose the parts of the story he or she wants to tell or discuss.

The function of inheritance in expressions of canonicity and breach is perhaps more obvious. Because the narrative breach involves a break from a canonical script, the same functionality is mimicked when an inherited narrative breaks from an established base narrative with a normal population of agents, events, time, sequence, and causality. If one of these elements is modified in a compelling enough manner, a breach occurs, and novelty is introduced into the inherited narrative. Here, the foundational narratives are determined by subject-matter expertise and the stated training goals and they are represented as pre-existing narrative objects in an electronic environment.

Narrative objects can also be used to parse precipitating events for several different narratives using polymorphic functionality. For example, in a computerized narrative system one might create a method named *GetResponse* that returns a team member's reaction to an event in the simulation. This reaction would differ depending on this particular team member's prior training and the current mission's objectives. The particular sequence of events during which a team member responds to a situation is different according to each team member's particular training and his or her objective in that mission, but the method for accessing these events would remain the same, that is, from TeamMember[1].GetResponse to TeamMember[*n*].GetResponse. In this scenario the various team members' stories are represented in a collection of objects from a range of 1, which represents the first team member, to the total number of team members, represented by *n*. A precipitating event is then discovered when an event or a series of events representing an individual response does not meet normal expectations. In other words, if a given team reacted in Fashion X to a given situation when they should have reacted in Fashion Y, it is possible to quickly scan through several critical parts of the team narrative on an individual level using common method names and dot notation. Any unanticipated individual responses would then represent potential points of departure from the expected team behavior (canonical script) as the actions of one individual might have more global repercussions on their teammates.

In sum, the features of narrative as described by Bruner (1991), and elaborated on here, present an effective means through which we can conceptualize DSBE and how they might be structured for debriefing. Furthermore, through the implementation of OOP we can see how this may be realized in a computational-based narrative system. Our goal was to provide an illustration of how the pedagogically sound concept of narrative can be integrated with the computationally robust technique of OOP to facilitate learning in distributed training environments.

CONCLUSIONS: DEVELOPING THEORY FOR DISTRIBUTED TRAINING

In this chapter, we have sketched a set of concepts and features from narrative theory, a domain that has already influenced a number of areas in the social and computational sciences. Using theoretically derived distinctions, we have parsed components of DSBE to illustrate how teams can be construed of as parts of event layers of a narrative and the team members as the actors and the interaction of these teams as the event structure of a story. When viewing DSBE feedback as a form of narrative system, we suggest that narrative can be the conceptual scaffold that uses stories for transferring critical information. These stories can be construed of as

> the means of packaging and distilling that knowledge into a format suitable for transfer . . . . In other words, a narrative system enables the transfer of knowledge and information using a packaging strategy without ignoring the social factors that help to shape that information. (McDaniel, 2004, pp. 90–91)

In addition to our theoretical consideration of narrative as it applies to a DSBE, we have outlined several characteristics and properties of object-oriented data structures suggesting that these types of programmatic models might be ideal for storing and manipulating narrative information in a computing environment. In connecting the properties of object-oriented languages to several of the important features of narrative, we have shown that narrative objects can exist and coexist in a computational framework without sacrificing the qualities that make the story such a powerful model for storing and classifying world observations and experiences.

As we discussed at the beginning of this chapter, this approach is a continuation of prior work that is building on psychological theory to aid in our understanding of training in distributed environments. The training space conceptualization, developed by Fiore et al. (2003), illustrated how critical learning events should be integrated to enable the linking of training concepts. Through the incorporation of memory theory into techniques to diagnose and debrief performance, Fiore et al. (2004) built on this approach and argued that memory hierarchies enable the development of principled methods for automating performance diagnosis and feedback presentation for distributed mission training. It is important to note that this prior approach for training using memory hierarchies is not at odds with our proposal involving narrative; instead, we view them as completely complementary. In particular, the hierarchical approach can be conceived of as a cross-sectional representation of the narrative, a slice in time across the unfolding story in which the actors are connected in a complex network of nodes. The purpose espoused with the hierarchical approach was to isolate a representation in which particular events can be viewed in parallel. In this chapter, we have built on that work to describe how narrative and story can be used to describe simulation-based exercises not in parallel but in sequence.

The unfolding of events in the distributed simulation and the interaction of actors within the mission creates the story that needs to be conveyed in a debrief. Narrative readily lends itself as a tool to support not only debriefing but also, more generally, the pre-, in-, and postprocess factors we have described as preparation, execution, and reflection, as one moves through a training space. Narrative can enable this process because it "operates as an instrument of mind in the construction of reality" (Bruner, 1991, p. 6), and in the present case the reality of what occurred in a given distributed simulation-based training exercise. Bruner (1991) ended his influential work on narrative by stating that he has tried to "describe some of the properties of a world of 'reality' constructed according to narrative principles . . . to lay out the ground plan of narrative realities." The daunting task that remains now is to show in detail how, in particular instances, narrative organizes the structure of human experience" (p. 21). Toward this end, we have made one small step by showing how narrative can be used to construct and convey the complex reality that unfolds during training so as to support a science of learning in distributed environments.

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