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The Moving Lens: Coherence across Heterogeneous Contexts in Narrative and Biology

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Abstract

Narrative can be considered a distributed system of intelligence: a sprawling network of inferences that connect diverse contexts, perspectives and forms of information. To synthesize these into a coherent fabric, a story employs mechanisms that are usually invisible to a reader. The result is a combined 'interpretive frame' that is accessible to all informational components, yet also changes as the story unfolds. This research tracks key operations of that process using a diagrammatic modeling grammar, using the example of the story *Red Riding Hood as a Dictator Would Tell It*. One goal is to model elusive qualities of narrative information such as ambiguity, tentative states, causal anticipation and managing unknowns, in a manner that can support reasoning systems. A current application is ontological interaction between models of biological processes in the body. This work focuses on the dynamics of a natural collaborative society, and is applicable in understanding how 'team narratives' evolve in an unfolding performance.

Introduction

This paper will report on an approach to contextual evolution that draws from the arts, and is supported by an extended version of situation theory (Goranson & Cardier, 2013). A key finding is that narrative employs multiple contexts simultaneously when inferencing, as a means of interpreting a piece of information. A diagrammatic modeling grammar has been developed to track how this activity modifies the causal affordance of participating elements. The model is currently being applied to the study of traumatic fear memory in biology, as an example of a naturally-occurring system in which separate processes adjust their behavior based on interaction (Cardier et. al, 2017). It serves as an example of how living systems build and modify a shared story as they evolve.

Two analogical leaps are thus entailed in the question of how insights from narrative can inform the performance of teams in context. First, an informational structure (such as a word) 'performs' its meaning anew every time it appears on a page, by virtue of the new contexts that bear on it. In each instance, it retains some implicit characteristics yet its role is formed by the preceding action. This recasts the semantic affordances possible for the word, sometimes pushing it far beyond its usual scope. An example is Duras' novella *The Lover*, in which the 'lover' is someone who is sometimes physically reviled (Ruddy, 2006).

Second: modeling this aspect of the narrative process reveals how diverse informational elements can act together to adjust the meaning of information. They do so by 'collaborating' to build a common frame of reference – this frame is the 'lens' mentioned in the title. It is communally derived so that all elements can participate in the shared product, even if not on their usual terms.

I observe this activity as an example of distributed cognition, following a definition of intelligence from Hutchins, as activity in which representations can be derived from different media and then "transformed, combined, and propagated through the system" (Hutchins, 1995). Cognitive narratologist David Herman describes how narrative particularly exhibits this kind of distributed intelligence. He gives the example of nested contexts, in which one story can be told within another. The embedded frame serves as "both [a] model for and vehicle of shared thinking, or socially distributed cognition" (Herman, 2006). In this paper, I extend this idea of a shared narrative frame further, to include the underpinning *ontological* framework generated when multiple narrative contexts are brought together (Cardier, 2013). The outlined model introduces new mechanisms to show how this frame of reference is constructed.

One goal of this work is to understand how **connections between multiple contexts** are built. Another is to track how this affects the **causal affordance** of participating elements. A final objective is to map the dynamics that emerge at the **system-level of contextual interaction**.

By 'system level', I refer to the tier of collaboration, as distinct from its individual components. When contexts interact at this level of the system, they communally behave in ways that are distinct from their composite elements. My work draws attention to system-level operations by developing a vocabulary to describe them, and a means to represent them. The example of traumatic fear memory in biology is explored, as an instance in which outcomes depend on shifts in dominance between different biophysical contexts, in this manner. My examination of contextual dynamics therefore spans two very different systems – narrative and biology – to identify common tools that can inform distributed, intelligent systems.

This work was first supported by a Navy-funded research project to develop new foundations for contextual integration among ontologies (Cardier, 2013; Cardier 2015). A current grant from the National Academies Keck Futures Initiative supports the maturing of this research, applying the analysis of ontological interaction to biomedicine (Cardier et. al, 2017, Goranson & Cardier, 2015). An underlying goal is to develop a clearer understanding of what systems-level dynamics are, and how they inform the changing capabilities of their components over time.

Defining *Context* as an *Ontological Framework*

Integrating knowledge in computer systems is a long-standing problem: it is difficult to connect sources of information if each uses different terms, knowledge structures, and causal dependencies. This incompatibility is termed 'heterogeneity' (Acampora et al., 2012; Berners-Lee and Kagal, 2008). In a computer system, heterogeneity occurs between the reference frameworks of different computer systems – such a framework is called an *ontology.* An ontology is used by the system like a dictionary, a reusable frame of reference. A common general definition is that an *ontology* records the "objects or entities that are assumed to exist in [a] domain of interest as well as the relationships that hold between them" (Gruber, 1993). When two ontologies have different structures, their information cannot be easily integrated.

Ontological heterogeneity can be correlated with the 'hybrid' aspect of teams, such that different operational abilities and knowledges must come together. Each member represents a 'context' of capabilities and information, which then collaborates within the larger 'context' of the given circumstances. This work focuses on how heterogeneity at both these levels can be integrated. In this respect, the resulting method can lend its vocabulary of ontological interaction to collaborative, hybrid teams.

This approach casts a *context* as a form of *ontology,* to leverage the following shared characteristics. Both a *context* and an *ontology* embed information in "a specific domain or situation" (Son and Goldstone, 2009). Both concern a group of entities and relations that combine into a system of causal dependencies – a scope of what-can-follow-what in a given domain (Einhorn & Hogarth, 1986). In both instances, this framework is limited. As Devlin notes, a *context* is "a limited part of reality" (Devlin, 2009). In ontology design, the limitations are a well-known source of frustration (Walls et. al, 2014). This is currently seen in the approach to standardize information across all systems so that no heterogeneity exists (Sowa, 2000), enabling one system to pick up where another leaves off.

In drawing this parallel, I move beyond beyond a general definition of context to one based on ontological parameters, in order to make it precise enough to be used by a knowledge system. The resulting method tracks contextual information as semantic nodes. When these are grouped, they can operate as self-contained contexts, which I refer to as *situations*. Both the individual and system level are represented, enabling the modeling of effects across these levels. The approach has been used to analyze real-world stories that could not be handled using existing methods, such as an episode from the television show *Game of Thrones* (Cardier, 2014) and *Red Riding Hood as a Dictator Would Tell It* (Cardier, 2015). The results demonstrate how narrative draws on reference ontologies in a similar manner to knowledge systems, but with one key difference.

The difference is: a narrative deliberately provokes inferences to contexts that are heterogeneous. It can even integrate them without losing most of the relevant contextual nuance (Cardier, 2013). This creates an ambiguity that has a specific purpose – to adjust the structures of common knowledge, until they reflect the nuances of a given circumstance. Following are key narrative mechanisms that enable this process.

Context in Narrative: Collaboration

To understand how narrative links diverse contexts, I began with an issue central to writing practice. How can a reader anticipate the ending of a story they can't predict? The question concerns reasoning across changes of state, as successive contexts.

A narrative *deliberately* generates dissonance between its states: from one circumstance to the next, between characters, and between inferences and their supporting reference frameworks. In narratology, this dissonance has been variously described as a 'breach' (Bruner, 1991), the 'unexpected' (Toolan, 2009) or a 'deviation' (Graesser and Wiemer-Hastings, 1999). By employing different kinds of dissonance, the story gradually tailors numerous general knowledge structures to one particular circumstance. It also generates causal anticipation.

For example, consider the title of the story *Red Riding Hood as a Dictator Would Tell It* by H.I. Phillips (Phillips, 1940/1993). The first phrase 'Red Riding Hood' depends on inferences to a context that includes a girl, a wolf, a medieval village, a simple moral code and some other rules of the fairytale genre. By contrast, 'Dictator' draws from a network that might include Hitler, world war II politics and the moralities of human control and survival. As such, the causal priorities in each of these situations also differs. In the *Red Riding Hood* context, death is caused by Red Riding Hood's carelessness plus a wolf; in the *dictator* instance, death is caused by the whim of the dictator.

These contexts cannot be easily connected due to differences in both their terms and structure. There is also nothing in general knowledge to indicate how to link them. Handled well, this incompatibility can benefit a story, making its reader want to know how it ends. If 'fairytale' and 'dictator' had a commonly known relationship in general knowledge, that reader would be able to draw on those ready assumptions to predict what would happen in the tale. As Graesser and Wiemer-Hastings note, "A story would fail to hold the attention of an adult if it perfectly meshed with world knowledge" (Graesser & Wiemer-Hastings, 1999). Instead, with no obvious connection, the reader must consume the story until its resolution. Causal anticipation is thus generated.

The process of integrating these contexts begins when the reader reaches the end of the title phrase "as a….would tell it". This connective idea of narration has the effect of nesting one context inside another – the agent in one framework becomes the narrator of the other. This first connection between separate situations provides a basis for understanding how to relate their divergent terms. It is not achieved all at once; instead they are progressively stitched together, node by node, as the story progresses. These new relationships adjust the information from separate general knowledge sources, to demonstrate how these contexts are connected *in this instance*.

Given the information so far, the nested structure indicates that the *dictator* causal framework will likely constrain information from the *Red Riding Hood* context. This new relation will be recorded tentatively as a dominant relationship, awaiting confirmation by later text. This dominance can be expressed as one of a few different kinds of *governance* relation. As this is a key feature of the model, I will pause to explain it.

Governance manages the inheritance issues that arise when two different system-level structures interact, focusing specifically on collaborative principles. It indicates the degree that one context imposes its structure on another. This is a spectrum of influence: the structure of one system can **replace** the other, **modify** the other or **collaboratively negotiate** with the other. This explains how different system structures can find initial points of connection; for example, when one is dominant, it adjusts the structure of the other towards itself.

In this case, the governance relation is tentatively recorded as *modify*. This guides the next step of integration, which occurs at the end of the first sentence:

Once upon a time there was a poor, weak wolf. (Phillips, 1940/1993).

The phrase "poor, weak wolf" inverts the commonly known fairytale role of the wolf, from predator to victim (Cardier, 2013; Cardier 2015). To correctly interpret this inversion, the reader must combine knowledge of multiple contexts: the traditional version of the fairytale, the dictatorial tool of 'propaganda', and some reasons why dictators use it. They must also correctly map these relationships across all active contexts. This activity enables the reader to correlate the characters 'dictator' and 'wolf'. The resulting interpretation is: the wolf is changing the Red Riding Hood story to make himself look good.

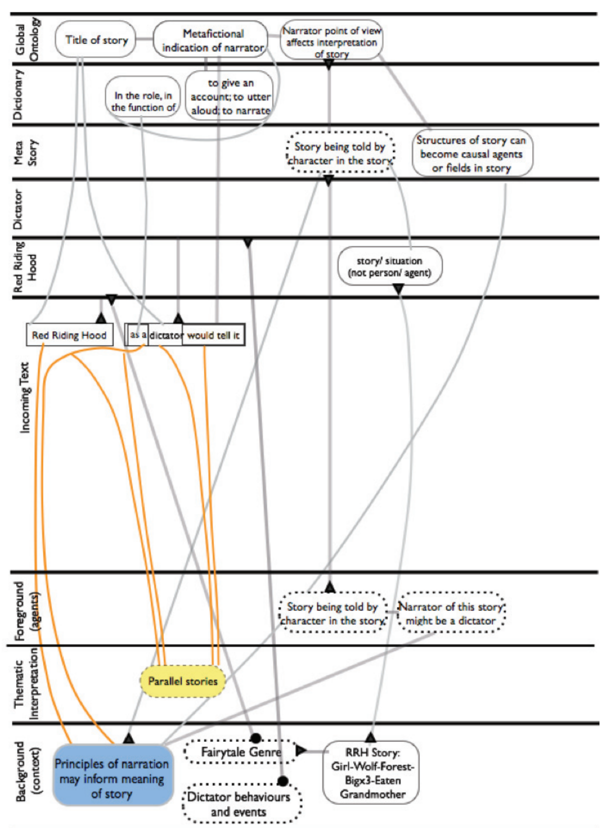

Figure 1: Early version of the animated narrative modeling approach – a still from the animation. Example from the story 'Red Riding Hood as a Dictator Would Tell It' by H.I. Phillips.

My modeling method outlines each stage of these operations, in animated form. See *figure 1* for an example of the amount of progressive connection needed to connect 'fairytale' to 'dictator' in the case of this story title. The result is a structure in which ontological networks are arranged as nodes usually are, a context composed of numerous contexts. This guides new incoming information. An overview of this method follows.

The Modeling Method

The details of this approach are complex; for the moment, it is enough to know there are three key main features, as indicated in the above *figure 1*.

First, the overall structure distinguishes between **general** and **context-specific** knowledge. Here, the context-specific knowledge comes from the circumstances of the story. In the graphical layout, these two kinds of information are represented by two separate areas. General knowledge is at the top. As the story triggers inferrences, their supporting reference situations can be drawn out as subsets of general knowledge (eg. *Riding Hood*, *Dictator*) – these are graphically pulled out like drawers. At the bottom, is the area in which new structures are assembled from these contexts, guided by the story.

Second, **situations** are built. Individual nodes from the two main areas (general knowledge and the story) are progressively stitched together. In order to maintain sense during this process, each newly created cluster of ideas is fenced by a discreet situation (represented as orange boxes or separate bands across the page). This new boundary preserves original ontological structure, while also indicating that one system is different from another.

Third, **connective structure** can join situations and nodes (shown as orange funnels and grey lines). Connective structure persists after a sequence of activity is complete (grey lines). Persistent structure can be reactivated when a new piece of information enters the system. When triggered this way, it can lend its semantic affordances to incoming information. The overall structure represents a higher-level encapsulation of *the story so far.*

These connective structures help identify the entities in the system that have **causal agency**. A causal agent is a contributor to an outcome. It is primarily identifiable through the degree to which it can bridge incompatible structures (Cardier, 2013; Cardier, 2015). The identification of causal agents is valuable for the purpose of understanding the probable cause of an outcome, or manipulating agents to change it (Einhorn & Hogarth, 1986).

Through these activities, collaborative structure emerges across heterogeneous sources. Links from general knowledge are anchored to new, evolving architecture. The whole system enables a reader to understand how separate contexts relate to each other. In this example, the reader can anticipate that *Red Riding Hood as a Dictator Would Tell It* will be a new version of the old fairytale, altered to reflect the causal priorities of a dictator. An implicit understanding of how contexts switch dominance and interact is critical to the accurate interpretation of this story. In order to make that process more visible, I model this combined, collaborative structure as a *causal lattice*, and represent it in the following manner.

A *causal lattice* is the 'lens' mentioned in the title. It is composed of the new relations a story has constructed, plus select general knowledge from each participating context (Goranson & Cardier, 2013). It is used by all semantic structures as a common reference point, to understand their roles *in this circumstance*. A visualization of a causal lattice by Goranson can be seen below, in *figures 2* and *4*.

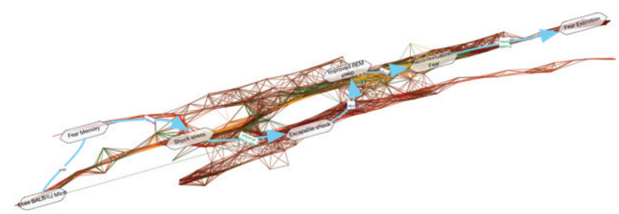

Figure 2: Connective structure in figure 1 matured with the above causal lattice, from the NAKFI project. Here, contexts are represented as event flows composed of infons, which are semantic statements from situation theory (superimposed).

Notice how the above structure is essentially a macro version of the network in *figure 1*. This overview enables a user to see how the shape of a system is changing, as it travels from left to right. Chains of morphisms track how the derived ontology evolves, which occurs as each new piece of information adjusts the system. As a user interface, the network can be scrolled, zoomed or adjusted.

The causal lattice models the 'lens' communally created by all narrative elements. It is also a visual representation of the way a reader keeps track of the changing nature of context when interpreting it. In the *Red Riding Hood* example, the reader quickly learns that the story will unfold according to a dictator's version of the fairytale, even though it is not possible to know exactly how this will occur. They can thus anticipate the end of a story they cannot predict.

The Arts: ambiguity, emergence and prediction.

This method draws on principles from the arts to understand how higher-level systems emerge and evolve. Artistic knowledge harnesses a top-down perspective, where sweeping characterizations of processes such as trauma or growth are possible. As Bruns observed of poetry, "Language is…a way of gaining and holding the world" (Bruns, 1974). Devices such as analogy and nesting enable complex relations across an entire system (Herman, 2006), and at the system level, these can capture additional properties that disappear when sought as individual elements. These include elusive, 'soft' forms of knowledge, such as tentative states, ambiguities and unknowns. These principles are modeled in order to supplement reductionist models of information. They do not replace reductionist methods; instead they incorporate and extend them (Goranson & Cardier 2013; Goranson et. al, 2015).

One of these mechanisms is specifically employed by narrative for state-change: analogy. Like a transition between contextual states, analogy must link structure across dissimilar situations. This asymmetric connection has been studied by cognitive linguists and developmental psychologists (Lakoff & Turner, 1989; Fauconnier & Turner, 2008; Winner & Gardner, 1993, Nersessian, 2008). Their work provides a second important observation regarding contextual integration: it has at least two levels. These are: 1) individual elements, and 2) how these behave as a group.

In analogy, these levels are understood as two tiers of meaning: "what is said and what is meant" (Winner & Gardner, 1993). More precisely, 'what is said' occurs at the level of syntactic expression. 'What is meant' concerns the system-level mapping between domains. This second aspect allows the discovery of structure from one in another. Lakoff notes that the system level is the primary influence on interpretation (Lakoff, 1993).

When one context is connected to another, whether as a shift in time or change of perspective, the same dual architecture emerges. At the reductionist level, there is a group of local definitions, terms or acts. This differs from the system level, in which these elements play roles as a unified whole. In both narrative and biology, shifts at this higher tier – the communal level – greatly inform the affordances of participating elements. A medical example of this will be provided in a moment.

Written narrative is not the only humanities domain that bears on this model. Cultural theorist Mica Nava describes the overlapping capabilities of context when she explains the layered nature of cultural identity. A person does not occupy one social context, she notes, instead each individual occupies many positions simultaneously (Nava, 1992). This dynamic lends insight to the way a piece of information can simultaneously draw from multiple contexts for its meaning.

Finally, a future direction of this work concerns principles of aesthetic design. The NAKFI project is currently investigating how characteristics of design might add a third tier to the architecture of state-change. Initial work suggests that after the second tier, which has the purpose of coherence, there is an additional layer, which refines this product into its most efficient form. In this third tier, the expression of information reflects the rules of its own construction: self-referential design. In collaboration with designer-architects Niccolo Casas and Alessio Erioli, this sponsored work frames principles of design in terms of the thermodynamics of energy conservation and optimal efficiency, to inform the transformations of the causal lattice.

System-level effects are a by-product of communal activity, and are conspicuous in the arts. They are not relegated to them, however. Collaborative dynamics also evident in other real-world information systems, where interaction across distinct processes is central. For an example, let us turn to traumatic fear memory in neurobiology.

Context in neurobiological treatment

The phenomenon of traumatic fear memory in neurobiology suggests that, in bodily systems, contextual integration also operates at least two levels. In this case, the contexts are the **cognitive** system (behavior seen in the physical neural circuitry of the fear memory), and a collection of **biological** systems in the body (the stress response seen in the immune and central nervous systems). When they interact, two tiers of interaction must be considered.

The reason: the treatment of traumatic fear memory depends on triggering a switch of governance between cognitive and biological processes. The result is that the cognitive system recontextualizes the behavior of biological elements, changing their activity (most notably, the hormone corticoliberan). For example, consider a person who has experienced a trauma and developed post-traumatic stress disorder (PTSD). The biological identity of the 'traumatic fear memory' prompts an immunological response (Sanford et. al, 2014). The unfortunate effects are stress, inflammation in the brain, lowered immunity and sleep disturbance. These symptoms emerge because the immune system cannot easily distinguish between a viral invasion and a persistent bad memory. In some cases, the body tries to fight the memory in a similar manner to fighting an infection.

Treatment of these negative effects depends on which system is dominant - cognitive or biological (Sanford et. al, 2010). If the subject is re-exposed to the trauma while being given control over those circumstances so they can escape, the cognitive system is able to take dominance. The subject effectively learns a new notion: that the original threat can be controlled. With the merging of the concept of 'control' and recall of fear memory, corticoliberan expression recedes. As a result, the body revises its biological 'memory,' eliminating negative symptoms caused by the attentive immune system.

The shift in dominance between biophysical 'contexts' has thus altered the body's immediate ability to manage traumatic fear memory, as well as its long-term understanding of how to react to that sort of threat.

This example has parallels with the governance exhibited shift between context that occurs in narrative inference.

In both narrative and biological examples, one context imposes its causal structure on another. This can replace or modify the priorities of the non-dominant system and new actions become possible. Demonstrations of this phenomenon enables a clearer understanding of collaborative, higher-level dynamics.

Visualizing collaboration: a higher tier

Visual modeling of any phenomena is important to understanding it (Johnson-Laird, 1981). This is particularly the case with contextual interaction (Cardier & Goranson, 2009). There is a lack of models that account for the system level – in fact, the focus on reductionist knowledge means that it is sometimes difficult to even draw attention to system-level dynamics. This lack has been lamented as a barrier to progress in systems biology and machine reasoning (Noble, 2008). In my examples, I have found that the stepwise, changing nature of the overall structure, plus the often invisible relationship between lower and higher-level processes, has meant that semantic book-keeping has been necessarily diagrammatic before it could be rendered in logic (Cardier & Goranson, 2009).

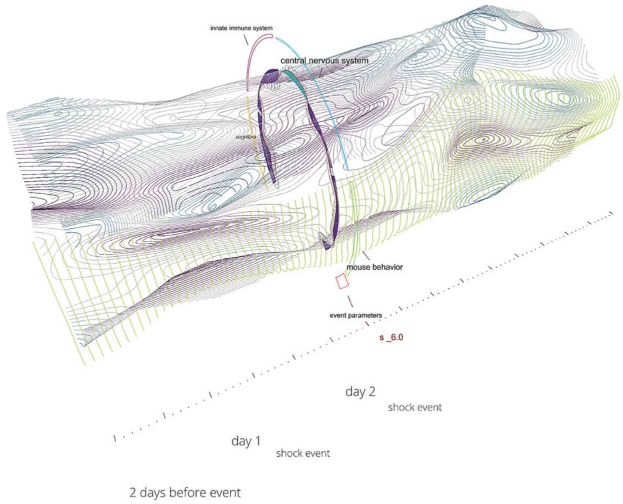

Figure 3: Visualization studies from the NAKFI project. A challenge is to display contextual interaction. Here, fear memory is represented by a flow of interacting processes. Relations are lines and interacting contexts are colored zones.

One goal of this work has been to graphically represent the system-level behaviors described here, making visible the dynamics between whole communities. Developing these visualizations is another goal of the NAKFI project. See *figure 3,* above, for an example created by Alessio Erioli and Niccolo Casas.

To implement this work, ordinary machine logic was supplemented with a second structure that could support the kinds of information found in narrative transitions: unknowns, ambiguity, tentative states and causal anticipation. Situation theory (Devlin, 1995) became the formalizable basis for this work. Details of this method follows.

The modeling method: formal foundations

The formalizable foundation of the modeling method is situation theory. Originally developed to address contextual reasoning at Stanford during the 1980s – 1990s (Barwise & Perry, 1983; Devlin, 1995), this method is distinctive for being a two-sorted logic. In this approach, two reasoning frameworks are linked in a formal relationship. One of these, known as the 'right hand side' (RHS), is the ordinary, logical system that handles individual facts. On the 'left hand side' (LHS), Goranson and Devlin added a new framework to handle contexts and their transitions. This 'second sort' can handle the stepwise operations required to bridge states because they are based on narrative mechanisms (Goranson and Cardier, 2013). This adjustment to situation theory addresses several challenges to its implementation, and the result is its first practical computerized implementation (Goranson & Cardier, 2013).

Our new situation-based approach is similar to solutions that employ modal or higher order logics for similar purposes. What differentiates our second reasoning system is that it is not logical, nor even set-theoretic. It cannot be, because the primary challenge is that it supports reasoning over open sets (that is, most situations have unknown defining facts). It also supports reasoning over transitions between these states; narrative structure also differs from that of logic in this key respect (Bruner, 1986). This approach can thus handle situations at the system-level: what they are, how governance is arranged and what meanings they affect.

This second reasoning system is implemented using category theory. Operations in one sort affect the other. For example, when a new fact arrives, it changes the situation arrangements. These are reflected in the categoric side (LHS) and the situation governance usually changes. In turn, this change modifies the relevant ontologies on the RHS that determine the 'meanings' (usually several) in the story.

Our emphasis on system-level state change means that the approach must also be geared towards connecting structure across similar situations. Type and category theories are well suited for this purpose. Using a vocabulary of known possible dynamics among situations, we model dominance relationships that, from a logical perspective, appear complex. As new facts appear, the story progresses or the team performs, the governance relations shift.

This framework has been published as a methodology and primitives for a type system that satisfies implementability of the formalism outlined here (Goranson et. al, 2015). The underlying situation theoretic structure also informs the visualization method. Each fact is represented by an infon, which is the unit of situation theory. Infons are composed into lattices – for an example, see *figure 4*, below.

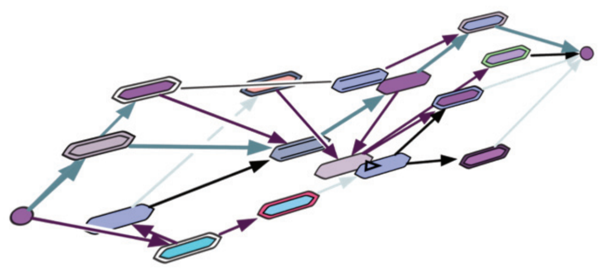

Figure 4: Close-up of figures 2 and 3 – infons structured into a causal lattice.

This graphical modeling method can capture the effects of narrative-based transitions and can also demonstrate which situations are active. When structure is tentative, it is indicated by dotted nodes and lines – in this way, ambiguity or multiple possible interpretations are recorded and collapsed.

Together, the combined structure of infons forms a *causal lattice*. In the visualization, this whole structure is animated, to capture the way the causal lattice evolves. Each node in the network is a statement of facts, which one can equate to the literal story chunks of the *Red Riding Hood* or data from a bioinformatics system. Logically, each link is an 'and-then' relation (Lehmann, 2008) that in part conveys temporal causality by the node and all before. Nodes are typically mappable to natural language concepts so can be 'read' and can be zoomed-into for constituents. Situations are depicted as distinct interacting networks of shape or color. A user is able to move back and forth in time to see change.

The NAKFI study attempts to impose an explicit display of situation influence to annotate this lattice. A recent experiment is shown in *figure 3*. This 'shell' moves left to right over time, as does the lattice, which is nominally inside as a three dimensional object. A trained analyst will be able to read the system influences from the colors and forms to get a feel for what systems govern that particular point in the event stream. In this study, developing a vocabulary of transitions is also a focus.

Our new model is thus developed to capture the phenomenon of contextual interaction, using a two-sorted situation-theoretic implementation extended by narrative-based mechanisms. In brief, the new collaborative dynamics it describes are:

• Inferences from multiple contexts can simultaneously bear on facts, acts and assemblies of them.

• This multiplicity is managed by a property called ***governance***, which arranges participating contexts into dominant and supportive roles. Governance handles inheritance issues that come with multiple, simultaneous inferences. The dominant context imparts its own associative priorities to the others, changing their affordances.

• The ***causal lattice*** is a coherent structure composed of connections among select and circumstantially relevant information from any context. It acts as a common reference framework, and is the 'moving lens' that informs the behavior of all participants.

• As circumstances progress or more information is added, the causal lattice's structures evolve.

• When this occurs, the lattice's fundamental affordances are altered, pushing them beyond their original constraints.

• ***Causal agents*** are responsible for connections between these heterogeneous structures. The more heterogeneous these are, the more agency is entailed.

These new mechanisms of contextual integration have been developed to track contextual interaction. They will be described in the presentation using an animated version of the modeling grammar. They can also be viewed online at http://info.bethcardier.com/index.php/models/.

Conclusion

This paper presents a narrative-based model of contextual interaction. It shows how ontological coherence can be derived across multiple situations, even if their structures are heterogeneous. Our diagrammatic model illustrates how this is possible: individual elements interact to build a common frame of reference. In this process, components assemble through mechanisms of context-building and integration. These contexts, in turn, are managed by the principle of *governance.* The resulting communal structure is continually altered, in response to each new event. We represent this model as an implementable method as well as a visualization.

Implementation is based on an extension of situation theory, which enables transitions between logical states. This work is currently being used to model the neurobiological disorder of traumatic fear memory, to explore how interactions between distinct processes change their behavior. Common principles are thus identified across both narrative and biological systems. In this respect, the distributed 'intelligence' system of narrative can offer insights to collaborative, heterogeneous teams.

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