THINKING IN STORIES

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Dedicated to my lovely, ever-patient wife, my ever-exuberant and mostly-sweet daughter, and my hopefully-punctual incoming son.

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SUMMARY

This thesis considers cognitive narrative a component of intelligence that specializes in generality. In exploring the ubiquitous external (mediated) and internal (cognitive) functions of narrative it provides two contributions to the literature: a uniquely cross-discipline survey of narratology that bridges humanities, social science, and computational fields; and a theory to generate cognitive personal narratives from ongoing perception. The implications of narrative cognition and cognitive narrative are discussed as well as the limitations of this introductory theory and the grounds for promising future work.

CHAPTER I

INTRODUCTION

The goal of this thesis is to provide two contributions to the fields of digital media and narrative studies. The first is a broad survey of narrative scholarship that establishes narrative itself as essentially general and cross-disciplinary, and supports the fundamental cognitive importance of narrative. This survey brings to bear theory and direction that supports the second contribution: a theory of cognitive narrative that extends psychological theories of perception and cognition. The theory proposed recognizes narrative cognition as an essential human faculty and provides a starting-place for models capable of capturing life-long narrative learning, experiential narrative generation, and eventually capacities like narrative comprehension.

Despite advances in modern psychology and neuroscience the human mind remains the most important undiscovered country. One certain fact, however, is the centrality of narrative to the human experience and our history, societies, religions, art, and entertainment. In our daily personal experiences we consume stories ravenously and produce them prodigiously; even when we aren't answering social media's plea to share our stories our text messages, conversations, and thoughts themselves are spinning a continual tapestry of narrativized meaning. Yet despite story rising alongside language as one of the ubiquitous and definitively human powers of our species, research into its cognitive roots and effects is an endeavor that has only recently begun. Despite some qualities of youth as a science, narrative is in the unique position of straddling the boundaries between disciplines of all kinds and brings to bear considerable insight from the literary and artistic fields even as brain studies and psychology continue to delve into the neurological bases of storytelling and story understanding.

As opposed to the formal study of narrative, mankind's experience of narrative dates to our earliest genesis. Despite the establishment of narrative into our very nature, our experience of it is forced to adapt with the sophistication of life and the technological development of the media that transport narrative to us (or transport us in narrative). Modern storytelling transcends its oral origins and can work, verbally and non-verbally, across the spectrum of perception; through games stories become interactive on unprecedented levels; and as artificial intelligence (AI) promises to interact with us in increasingly personal and interconnected ways it becomes ever more important for us to explore both the ways we experience narrative and the ways of sharing some degree of this human quality with the systems that interact with us.

In this work the goal has been to explore narrative with cognitive systems that can simultaneously offer insight into human thinking and produce new ways of reasoning for AI agents. An ideal test bed for these early agents has been within the space of video games. One value of using video games as a domain for this kind of research is that they offer forgiving simulations with controlled degrees of complexity. Nonetheless the system employed here has also been successfully used for complex robots and military-grade AI applications, so that insights at the game level can look forward to extension to more complex realities.

Another benefit of video games as a domain is the natural amalgamation of literary and artistic creativity, both new and established, with technology. In this they parallel narrative research itself. Even games as simple as *Fruit Ninja* are part of a culture that admits ninjas, knights, dragons, and magic as they push forward for improved technical innovations. Throughout this thesis a similarly holistic approach is taken. Sections are ordered according to the overarching exploration of narrative itself with interdisciplinary contributions considered each step of the way.

This work articulates a theory of narrative cognition that is considered through the perspective of implementation in the Soar cognitive architecture. In particular, this work considers the episodic memory that is built from the life-long experiences of the agent. For a human, memory for experiences is inextricably narrative in nature: it is almost impossible to separate the memories from the stories we tell as we consider and communicate them, and the details of the memories shift as much as does any told and retold story. Human memory is fundamentally creative. This differs significantly from computer memory, which is excellent at encoding rote facts in detail but does not naturally lend itself to analogy, creativity, or sensible constraints of attention. While human memory certainly begins as raw data from our perception, this subject of this work is an AI that is able to narratively process that data to produce something that seems more humanly episodic: memories of a form with a beginning, middle, and end, upon which further components of narrative intelligence can be built. Put another way, this work is an effort to confer to an AI an understanding of what narrative is, and give it the first tools in how to use narrative in its thinking.

The theory for narrative cognition that is introduced here has a bearing on human's life-long narrative capacities, and provides a starting point intended to be similar to the human starting starting as children, where the young begin by making narratives that seem simplistic or uninteresting to more experienced narrators, but which establish the narrative base which is the foundation for more advanced narrative cognition. Future work should be firstly concerned with the learning mechanisms by which narrative cognition feeds itself and develops with experience. Other important future work will crucially include narrative comprehension by which narratives are generated from other than first-hand experience of events, and advances along each of the lines of cognitive instrumentality laid out in section 2.3.

This thesis is structured as follows. Chapter 2 considers the nature and definition of narrative. First narrative is considered as an independent concept, as distinct (or indistinct) from story. Concepts of the subject from literature and psychology are considered in terms of the functional and practical implications of the differing concepts. Next situated concepts of narrative are considered, which regard narrative within social and systemic contexts. Features particularly important to precise modeling are considered. The chapter next considers the topic of narrative intelligence and the cognitive activities that for which narrative can be applied. In particular, story generation, story comprehension, and story telling are each considered. Investigations in this chapter are guided by the question, what difference does narrative intelligence make?

Chapter 3 extends section 2.3 on cognitive narrative by considering psychological and neural mechanisms. It first reviews the psychological apparata of episodic memory and the relationship between human episodic memory and narrative. The second portion of the chapter introduces Event Segmentation Theory (EST) [56], upon which this thesis' theory of narrative cognition is based.

Chapter 4 starts with an introduction of cognitive architectures in general and the Soar architecture in particular. It considers applications of Soar in digital media applications. It concludes with the development of a theory of fundamental narrative cognition built upon EST in Soar.

Chapter 5 concludes by taking stock of the theory from chapter 4 and considering its strengths, limitations, and future directions. The application of the work is considered for cognitive science, games, and expressive AI.

CHAPTER II

NATURES OF NARRATIVE

While even linguistic universals are challenged as experts explore the cultures of the world, there has been found no exception to the universality of stories and storytelling. Every culture and society across the world seems to use stories in one way or another, and stories seem to be a key tool for humans to understand time and experience. Because of this prevalence, the subject of narrative has found its way into a plethora of fields of study including psychological, literary, media, and computational fields of research. This has the advantage of providing a rich variety of viewpoints and perspectives upon the subject, but this advantage is double-edged. With the increasing number of perspectives on the subject of narrative has come complication of what narrative actually is. This complexity has had a prism-like effect upon the definition of narrative, with each field constituting a lens that captures a different spectrum of narrative. But, like a prism's rainbow, these many perspectives on narrative offer insights that contribute to the conversation on narrative across media.

In this chapter we take up an exploration into the nature of narrative, sampling from a range of approaches. We begin with a brief discussion of terms, particularly of *reader*. Section 2.2.1 reviews some of the central concerns of narrative theory, which has long been occupied with the question of the structures that narrative can take. In particular, narrative structuralism is considered not only in its original explication by folklorists like Vladimir Propp and from theorists like Barthes and Genette, but also in the work of modern computational theorists who consider these earlier approaches foundational.

The structuralist analyses of narrative and of the experiences narrative fosters have developed into the field of cognitive narratology, discussed in section 2.3, which considers the bread-and-butter conversational structure and role of narratives in day-to-day life, as well as theories of the internal roles of narrative in the mind. This chapter concludes with a consideration of the important similarities and distinctions between cognitive narrative, intelligence for narrative, and narrative for intelligence.

The discussion of narrative intelligence foreshadows section 2.4, wherein the connection of narrative with efforts in artificial intelligence is considered. AI approaches narrative as something to be applied, either as a tool for intelligence or as an object of intelligence. This notion extends beyond the field of the artificial to the every-day human use of narrative for negotiating reality.

The chapter concludes with an overall summary and a highlight of particularly relevant contributions to the theory of this thesis from the considered fields.

2.1 Coming to Terms with the Reader: A Note on Narrative Recipients

Before we launch into a discussion of narrative as an object and of the effects of narrative it is necessary to establish a standard term for the one whom that narrative effects–the one who, if narrative is a conduit of meaning, is the recipient of that meaning; or if narrative is a function, upon whom that function principally acts. Viewpoints emphasizing the role of narration in the narrative have also sometimes termed this person the narratee (as in sections of Barthes' work [9]). Common ground between the literary, rhetorical, and dramatic fields has been achieved with the term *audience* [104], while the theatrical and movie circles also readily refer to *viewers*. Narratives are often discussed in communication and marketing studies with reference to story *consumers* [33], a term which is certainly general enough to apply across disciplines but brings with it a context of commercial appetite that may not be desired. And none of these are a particularly familiar fit for gamers, whose interactivity with narratives is particularly highlighted by the term *player*.

In this thesis the term **reader** has been chosen with reference to the primary recipient(s) of narrative effect. While the action of reading may not at first seem to be as applicable to non-literary or non-textual media, this term is useful for several reasons. Firstly, it unites our terms with the standard across the bulk of narratology, even extending to discussions of narrative kinds like Barthes' *readerly* texts [9] (again, not strictly referring to the literary). Secondly, reference to the action of reading emphasizes the process of active sense-making; this interpretive action is one of the core functions of narratives, both as mediated texts and in the mind, and will be useful even as we discuss, somewhat less conventionally, readers of films and games. This is not a completely foreign usage of the term since the metaphor of reading is readily applied when we ask someone's reading of a film or a situation. This term prompts productive questions when considered with cognitive narrative (section 2.3), a case in which the author and the reader might seem to be one and the same.

2.2 Narrative Structure

2.2.1 Dramatic- and Plot-structures

The search for the structure of narrative, singular or manifold, has guided the genesis of narrative studies, and precedes efforts to generate, comprehend, or communicate them. This interest dates to the earliest periods of literary criticism. Aristotle, ever influential, offers us the concept of narrative consisting definitively of a beginning, a middle, and an end [23]. While this simple concept of narrative fits with easy intuition of the nature of narrative, its implications should not be overlooked. Such a clearly delineated structure for narrative heralds a separation the substance of narratives from the seamless experience of life; it's unrealistic in some of the best ways. This dynamic division between life and narrative will be further considered in section 2.3. Even the simple tri-segmented definition can be considered a de facto standard until the advents of modernism, post-modernism, and post-structuralism would develop to

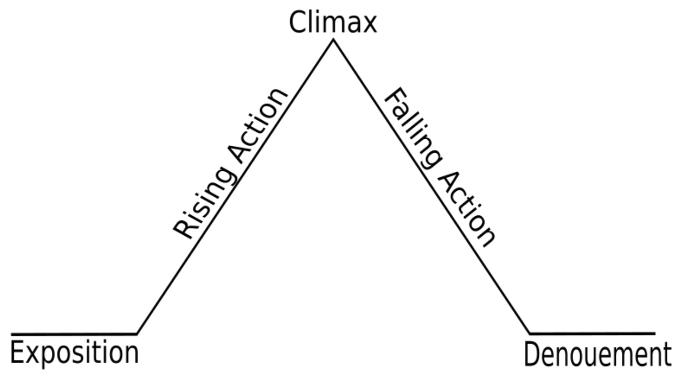

Figure 1: Freytag's Pyramid of dramatic structure [39]

challenge this notion.

While the Aristotelian structure of narrative may seem overly simplistic for the modern needs of many scholars, it is for this very simplicity that it has been valued for so long by those who seek a platform to start from. The indelible magnitude of *Poetics* impact upon critical thought for literature, drama, and other fields is at the heart of much work by Classicists and is beyond the appropriate scope of this thesis, but among its repercussions was the development of dramatic structures such as Freytag's Pyramid [39] (image 1), which augments Aristotle's three-part structure for drama with rising and falling patterns of action intensity. These concepts of structure conceive of narrative from a dramatic, rhetorical perspective. Here, narrative is structured according to its effect upon the audience or narratees. The subject of these paradigms is narrative to be consumed, largely for entertainment; as such, its goal is structures which can be natively understood and comprehended with a little barrier to entry as possible.

This dramatic approach to narrative, with its immediate appeal to the general audience, focuses upon plot: the high-level sequence of the events that are crucial to a narrative. So great is the human appetite for narratives that these sort of plot-centric views have continued to bear fruit. The literary invention of the novel

653

(651-*) (652b-*) (655-*) (661) (1267a) (1419b) (662 ch A-2 to A-5)
A is a captive, held by his captor, A-5, in a physical environment which constitutes a trap, and from which there seems absolutely no means of escape * Nevertheless, A, with desperate determination, seeks to free himself by subtle enterprise ** (651*-**) (652b*-**) (655*-**)

Figure 2: An example *Plotto* entry, indicating the gist of this segment of the story and what segments could follow

produced a new way for consuming narratives and the nickel- and dime-novels of the early 20th century profited from feeding this appetite in newer, faster ways. In this context we see informal exploitations of a plot-centric view of narrative in works like Cook's *Plotto: a new method of plot suggestion for writers of creative fiction* [26]. In this volume, and in those like it, the author offers resources for the would-be story-generating author. Cook's book undertakes to achieve creative art by what he calls "plot suggestion," by which story clauses are stitched together under the guidance of, or to the emergence of, over-arching themes. Plotto explicates a basic algebra of characters and agents, guiding the user through constructing a plot that need only be fleshed out to become, presumably, a best-selling novel. A sample from Plotto can be seen in figure 2.

Cook's system is a predecessor to computational algorithms for narrative generation and demonstrates the plot-centric concept of narrative that is popular for entertainment and mass-production. It shares with eventual computational approaches an audience-centric view of narrative that is concerned primarily with productivity, as opposed to theoretical descriptiveness or psychological appropriateness. These productive, plot-centric approaches can provide insight into general narrative trends and data for further analysis.

In addition to generative approaches that share with dramatic narrative an interest in the general audience, a second significant contribution from the dramatic approach to narrative stems from the work of Kenneth Burke, a rhetorician and literary theorist who developed the theory of dramatism, which applies directly Shakespeare's

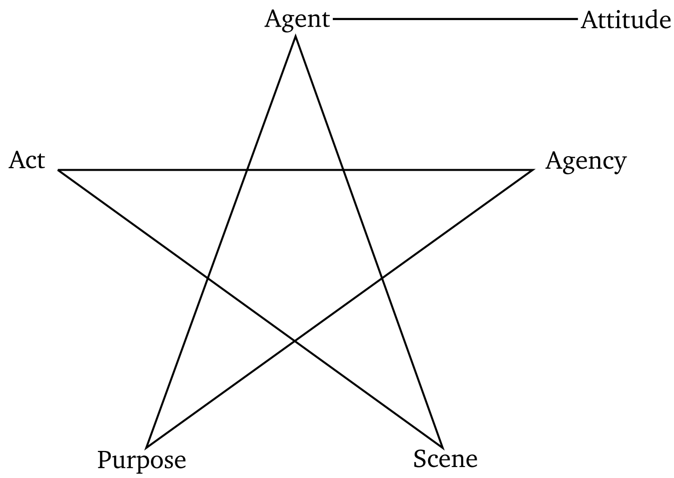

Figure 3: Burke's Dramatism Pentad [20], illustration from West & Turner [134]

metaphor that "All the worlds a stage, and all the men and women merely players" [121] as a philosophy of human communication and relationships which has impacted a wide range of fields [19, 21, 134]. Burke's model situates *agents* within a *scene* where *acts* are committed for the *purposes* of the agents, according to the agent's *agency* (the Dramatism Pentad, figure 3).

Burke's paradigm was formalized into narrative terms by Walter Fisher, who developed Narrative Paradigm theory with the notion that all of human experience can be considered a practice of story telling (structured according to the Aristotelian distinctions of beginning, middle, and end) [36]. Fisher's concept of narrative as primarily a sequence of events allowed him to frame the paradigm as an all-encompassing theory of more universal scope than literary approaches allow, somewhat in agreement with cognitive (2.3) and computational (2.4) generalizations. The Narrative Paradigm is further discussed in section 2.3, but of particular value from the theory is Fisher's definition of **narrative rationality** as centering upon fidelity and coherence; that is, by the degree to which a narrative "rings true" with the experiences and values of the receiver (fidelity) and the degree to which it is plausible and cohesive within the reckoning of its own story world (coherence) [36, pp. 24-25, 156].

2.2.2 Proppian Narrative Structure

Long before the advent of the novel mankind's hunger for narrative caused the development of folk tales. These are the object of the study of Vladimir Propp, a Russian Structuralist of the early 20th century now considered one of the fathers of modern narratology. Unlike dramatic perspectives on narrative, Propp removed audiences and, to a degree, even drama from consideration; the narratives themselves, instantiated in specific tales but forming a genre of Russian folklore altogether, were the subject of Propp's research. Meticulously analyzing dozens of folktales from a corpus collected by Alexander Afanasiev, Propp eventually produced his landmark analysis, *Morphology of the Folktale* [105]. From Propp's work the field of narratology developed the ideas of a three-part structure of narrative, consisting of fabula, sjuzhet, and text or media.

Where dramatic narrative structures derived from Aristotle's three parts are concerned with the external form of narratives as received by an audience, the narratological structures developed from Propp's work consider the structure of narrative internal representation. In this way they share something in common with Chomskyian notions of sentence structure, which propose a deep structure of underlying semantics and the surface structure of the actual words selected. Likewise Propp's *fabula* constitutes a deep structure containing all events taking place in the story, whether communicated or implied. The fabula is considered to be ordered according to the order of the events. The *sjuzhet* is then the order and content preparatory to the actual telling of the story, which may omit items from the fabula and may order them differently (as, for example in cinematic narratives, when a flashback reveals episodes at a time other than their actual occurrence). Finally the sjuzhet is interpreted into whatever terms are appropriate to the given medium, resulting in the final product *media* (called the "text" in traditional narratology [8]).

Propp's three-part structure has become the standard of narratology. Starting with the fabula it offers a model that can capture the increasing complexity of a narrative, beginning with only ordered events and progressing to eventually arrive at the rich and ambiguous fullness of the text. Because of this clear developmental path it has been possible to functionalize some degree of narrative development in computational narrative generation. The fabula-sjuzhet-text process is well suited to becoming the model for algorithms. As will be discussed in section 2.3, however, the popularity of the three-fold narrative generation process for computers serves to highlight the rift that can exist between computer and human intelligence.

Propp also provided another resource for narrative generation efforts. Aside from the proposed internal structure of narratives, Propp focused up on the actions of characters. Assigning characters to different classifications, he found that the Russian folktales followed closely the same sequence of events throughout stories. Characters of certain types, placed in certain situations, predictably performed the same actions with little variation. He went to extensive lengths to codify these character-action formulas and produced the predecessor of the story grammars of the 1980s [116].

As has been indicated, the structuralist narratology pioneered by Propp is characterized by a simplicity and modularity that makes it and its descendants a useful basis for modern computational approaches (section 2.4). In particular it has been the direct basis of a number of narrative generation systems [34, 42] and a defining theoretical basis of many more [6, 111, 74].

2.2.3 Structuralist and Post-Structuralist Narrative

2.2.3.1 Barthes

Literary approaches to narratology are not necessarily driven by the same concerns for modularity and productivity as plot-based approaches. One of the landmark works from the literary perspective is Barthes' 1975 essay *S/Z* [9]. Meting out a deep micro-analytic framework for how narratives construct meaning, Barthes' approach holds any minimalist plot-based approach to generalizing the structure of narrative

Table 1: Barthes' five codes of narrative meaning, collected from *S/Z* [9]

Code	Explanation	Example(s)
Hermeneutic	Pertaining to questions and truth	"What is Terracing? A noun? A name? A thing? A man? A woman?"
Seme	Connotation; "the unit of the signifier"	Femininity, Cold
Symbol	Pertaining to rhetorical constructs or themes	Antithesis, Wealth, Emptiness
Action	Proairetic; events which have ends or results	"I was deep in [a daydream]. . . "
Reference	References to a science or a body of knowledge	". . . whose beauty embodied the fabled imaginings of the Eastern poets!"

to be repugnant; instead, his focus is upon the experiencing of narratives as they are attended. This approach is relevant not only to the reading of narratives, which was Barthes' central focus, but also to the watching, listening, and interacting with narratives that are made possible by modern media.

Barthes' proposes five codes present in narratives for the capturing of meaning (figure 1). In so doing, he proposes not a structure for narrative itself, which he argues should not be thought of as being constrained to a singular structure, but rather a language that holds for the human experiencing of a formal narrative (as opposed to the informal narratives of daily experience, discussed in 2.3).

By disregarding the notion of a static narrative structure and instead encouraging focusing upon the interaction we have with narratives, Barthes' pioneered an approach that highlights the sophisticated capabilities of narrative and the language and symbolism that narrative makes possible. His approach has contributed significantly to later work on narratology including cognitive narratology (section 2.3). Each of his five codes identifies aspects of narrative and narrative language that are built upon by later theories.

The hermeneutic code identifies narrative's capacity for defining a story-world that holds its own internal structure, rules, and truth. Barthes described this code as capturing "The various (formal) terms by which an enigma can be distinguished, suggested, formulated, held in suspense, and finally disclosed" [9, p 18]. A relation to the dramatic models of narrative can be detected, with the rhetorical powers of narrative being recognized by both. The quality of a narrative with respect to the hermeneutic code can be judged as its internal coherence in the world and characters it maintains. The concept of internal coherence invited by consideration of the hermeneutic code has become a come to be almost universally considered an essential component of the quality of a narrative not only from a literary standpoint but also from the psychological perspective [127, 81, 93] and the computational perspective [112, 138, 102]. While Barthes was opposed to a generalized structure for narrative, he succeeded in identifying a generalized quality.

The seme code is, by nature, an evanescent quality of narrative that Barthes described as "flickers of meaning," the atomic constituents that "combine with other similar elements to create characters, ambiances, shapes, and symbols" and "the unit of the signifier" [9, p 17]. They rely upon connotation for their meaning. The video medium offers clear examples of this quality, which could be identified not only by deconstructing the symbols (themes and tropes) it forms but also in the backgrounds and subtle details that serve to flavor or emotionally locate the narrative. In particular, semes reflect connoted meaning that arises from context and collocation with the seme itself. From a psychological perspective, semes are the most "bottom-up" of the codes, the least structural of themselves. Generative approaches to narrative largely overlook this element on its own because it operates by leveraging abstract general knowledge to create subtleties of representation, or else to be composed into the symbols that can be more easily managed and recognized.

Unlike the flickering semes, symbols are recognizable and discrete; to an extent, categorizations like Propp's are an indexing of symbols (and actions). Knowledge of symbols is distinct from the sort of knowledge that the referential code draws upon; rather than referring to properties of the world or to a body of facts, the symbolic code refers to themes and rhetorical mechanisms that operate at a more abstract level in the narrative. Of particular interest to Barthes is the symbolic mechanism of antithesis. *S/Z* analyzes Balzac's short story *Sarrasine* in which Balzac makes frequent and effective use of antithesis; for example, highlighted by Barthes in the line,

> Thus, on my right, the dark and silent image of death; on my left, the seemly bacchanalias of life: here, cold nature, dull, in mourning; there, human beings enjoying themselves.
>
> – *Sarrasine* [29], analyzed by Barthes [9, pp. 25-26].

Antithesis is a particularly powerful example of the code of symbols that serves to explore information about two concepts and the difference between them. As a symbolic mechanism it can be used frequently and compellingly to deepen the impact of a text and to centralize ideas in the flow of the narrative. This exemplifies the utility of the symbolic code, which builds upon a repertoire of tools that can be re-used, and hence serve as a more general language of narrative communication. These symbols can form a "vast ... structure" that can reveal an "immense province" that taps into the symbolic knowledge of the reader [9, pp. 17-18]. By nature, the symbolic repertoire consists of narrative mechanisms that may readily translate across media; for example, antithesis is as valid and poignant a mechanism in film as in literature.

The action code is familiar from the discussion of plot-based story structures, and is one of the most easily grasped by readers. It is into terms of actions that summaries and re-tellings of stories most easily arrange themselves. Barthes invokes the Aristotelian term *proairesis* in the discussion of the action code, by which he refers to the capability we have to perceive an action and immediately predict a result of that action. As Barthes points out, narrative adds a dimension to this proairesis by allowing predictions to be made based on narrative understanding that might not apply to other types of experience (or might apply, as will be discussed in section 2.3); for example, if we know that in an action story the good guys always win and therefore will not plummet to their death after dangling from the precipice. Our proairetic ability is fundamental to the model of cognitive narrative that will be considered in this thesis (section 3.3).

Barthes makes a point that his codes are in no particular order–they are, in fact, just the order he finds them exhibited in *Sarrasine*–but the final code is the referential or cultural, by which a text draws upon an established body of knowledge presumably known to the reader. Like the symbolic code, this indicates narrative's ability to orient pre-existing knowledge to a story, complementary to the in-story knowledge indicated by the hermeneutic code. However, this capacity has been both magnified and blurred with internal storyworld knowledge with the advent of transmedia stories and the encyclopedic affordances of digital media, as exhibited in online communities, story wikis, and fandoms [91], which have exponential increased the intertextuality that can be exhibited by narratives.

Barthes framework for analyzing the experience we negotiate with a narrative has deeply impacted the critical literary and narrative fields. Although his stance against narrative generalization is apparently contrary to the endeavors of computational narrative approaches (particularly narrative generation) that will be considered in section 2.4, Barthes viewed the text (the individual narrative object) as a system. In this way we see a similarity between Barthes description of narrative and, as loathe as Barthes might be to make such a comparison, a mathematical or programmatic function (rather than a data structure) in which the reader is the input:

> One does not narrate to 'amuse,' to 'instruct,' or to satisfy certain anthropological function of meaning; one narrates in order to obtain by exchanging; and it is this exchange that is represented in the narrative itself: narrative is both product and production, merchandise and commerce, a

stake and the bearer of that stake. [9, p. 88]

Barthes' elements of narrative provide concepts that can be seen and are utilized, directly or indirectly, throughout modern approaches to narrative and in even implicit capacities in the theory of cognitive narrative of this thesis.

2.2.3.2 Genette

Eight years after Barthes' pioneering *S/Z* came Genette's *Narrative Discourse: An Essay in Method* [40], a second pivotal work from the French school of narrative that has had monumental impact upon narratology and conceptions of narrative structure. Where Barthes approach emphasized narrative as an indissoluble transformative function, Genette takes a much more structured (and somewhat playful) approach that considers narrative from a level of abstraction higher than the word-by-word analysis performed by Barthes. He produces a framework of lenses that capture more general elements of narrative, which are cognizant of–and pressingly relevant for–narrative as a practice and form across media (influencing, for example, critical film theory [52]). Where Barthes focuses on word-level encodings, Gennette's theory complements Barthes' by capturing broader strokes that hold over passages or whole narratives.

Genette establishes three "ambiguities" of the word *narrative* that are sometimes today as overlooked as they were at the time of his writing, and which form useful distinctions and are cited in table 2.

It is particularly important to recognize these ambiguities of the term "narrative" because of the interdisciplinary ubiquity of narratives, and that different disciplines may readily employ different primary concepts. Although Barthes did not explicitly recognize this ambiguity in *S/Z*, he and Genette share a focus upon definition 1–that is, narrative as an object of discourse which, therefore, submits to textual analysis. In respect for the ambiguity that overloads the term "narrative," Genette distinguishes

Table 2: Three meanings of "narrative" and Genette's terms for them [40, pp. 25-26]

Term	Description
Narrative	The narrative statement, the oral or written discourse that undertakes to tell of an event or a series of events
Story	The succession of events, real or fictitious, that are the subject of this discourse [from definition above], and to their several relations of linking, opposition, repetition, etc
Narrating	The event that consists of someone recounting something: the act of narrating taken in itself

between the three terms with narrative, story, and narrating, respectively.

Of particular importance is Genette's distinction of *story* from *narrative*, in which story represents an underlying content similar to Propp's fabula. Genette's definitions of story and narrative have led to a divide in modern usage across fields, with literary scholarship often adhering to Genette's terms (e.g. Rimmon-Kenan [113]) while work in computational and cognitive narrative either merge the notions of "story" and "narrative," using both of them to refer Genette's second (fabula-like) definition while giving less attention to either of Genette's "narrative" or "narrating" concepts. To some extent we can see in this a divide as to whether to adhere more closely to Western or Russian concepts of narrative structure.

Genette produces a three-fold system for examining narrative. This system is concerned with the relationships that hold between the narrative and story and between the narrative and narration. For the former relationship he discusses the concepts of *tense* and *mood*, while the concept of *voice* applies to both relationships.

To the point of narrative structure, tense is the most applicable. This receives Genette's lengthiest attention and highlights narrative's fundamental concern with the temporal and the sequential. Genette considers three dimensions in which narrative concerns itself with temporality: the order of presentation, the duration in which content is represented, and the frequency with which a narrative refers to elements of the story.

Order remains a center of discussion in matters of narrative, being perhaps the most easily comprehended and manipulated. This is particularly applicable in the modern narrative, as technology has made editing and restructuring unprecedentedly simple for virtually every form of storytelling from the literary to the visual. Indeed, Genette recognizes the inherently more static nature of natural language as a medium, pointing out that movie frames or comic strip panels can be literally presented in reverse for differences of effect while the constraints of language do not allow for such low-level re-sequencing while retaining comprehensibility [40, pp. 33-34]. Perhaps one of the most widely-known explorations in narrative reordering is Christopher Nolan's 2000 film *Memento* [99], in which the story is revealed in reverse and concepts of time and perspective receive magnified importance [52, pp. 227-229]. Such explorations in narrative ordering, joining the *proairetic* human capacity discussed by Barthes (section 2.2.3.1), have highlighted a property of narrative that is now central to even the most minimal definitions of narrative: that of *causality* [128, 112]. In the very least it is the necessity for perceivable causality that distinguishes between a grocery list and the sparsest story or narrative.

Genette's topic of duration is prescient of the developments of digital media insomuch as it is perhaps more clearly visible in non-textual domains. More familiarly characterized as rhythm, this element highlights the distinction between Plato's *mimesis* (exactly reproduced) and *diegesis* (purely narrative): narratives are rarely composed of entirely word-for-word quotations of dialog (or, for example, single-shot movies), and most significantly, the degree to which a passage of a narrative encapsulates more nearly a second or a year can and should be variable during the course of the narration. While presently difficult to manipulate with any deliberate facility in computational approaches to narrative, variation of narrative rhythm is an innate quality of our mental narrative representations as well (section 2.3).

The concept of frequency concludes Genette's discussion of narrative tense by complementing the concept of duration, how the narrative represents time, with that of how many times the narrative refers to events. While this has long been a consideration in textual analysis (for example Hebrew semantic repetition for parallelism and verbatim repetition for superlatives, both abundantly evident in the Old Testament/Tanukh [77]), it is also frequently displayed in modern visual genres like Japanese Anime and video games, which may replay a scene multiple times in quick succession for dramatic effect. Genette also calls our attention to the less-used property of frequency as exploited in the reverse: rather than multiple replays of the same instance, at one time referring to multiple events. Perhaps more difficult to apply in non-textual media, we see examples of this usage in references to "each night," or "all week" [40, p. 116] where we understand the phrase to provide information about a range of similar events.

Genette's discussion of mood draws us slightly away from considerations of narrative structure and the internal relation of narrative to story, and toward his third definition, the act of narration (figure 2). With this is highlighted the person and activity of the narrator, a dimension that often goes undiscussed in non-literary theories of narrative. Mood is concerned with what information is made available to the consumer of the narrative, and inversely, what information is withheld. Perhaps the most significant product of Genette's analysis of mood is the idea of *focalization*, which has been heavily drawn upon in narratology [8]. Genette's use of the term focalization is meant to capture each of the relationships of the narrator knowing more than the [lead] character, the narrator knowing as much as the character (in 1st-person narratives, actually being that character), and the narrator knowing less than the character (a common dramatic technique in theater or detective stories, for example). Importantly, focalization can and often is altered in the course of a narrative, and narratives can cycle through a closed cast of focalizers or can have a wide, oft-changing focalization. This concept is not insignificant to cognitive narrative, as is particularly evident when we express reflection with phrases like, "If I knew then what I know now," or inversely "I didn't know it at the time..." Focalization also bears on the psychological *theory of mind* by which we simulate the thoughts of others in our daily lives [44] (see section 2.3).

Genette concludes his essay with consideration of narrative voice. If mood is concerned with information available to the reader of the narrative, voice is concerned with the qualities of what is produced by the narrator and, in particular, the narrator's relation to the narrative. We might summarize it as concern with what, where, and by whom narration occurs. In particular are considered the time of narrating relative to the narrator (an inversion of the temporal concerns of ordering, previously discussed. Subsequent, the most ubiquitous form; prior, or predictive, such as biblical prophesy; simultaneous, such as a news cast or epistolary novels; and interpolated, in which the relation goes back and forth between these), narrative level (admitting nested narratives, such as Scheherazade's telling of stories within stories within the story of *Arabian Nights* [22]), and person (the relation of the narrator to the narration, such as Scheherazade's life depending upon her telling). While we have strong empirical expectations about normal or default narratives (for example, un-nested past-tense narratives from an omniscient/reliable narrator), the capacity for narrative to exhibit other voices is an important feature of narrative capacity. Non-standard narrative voices have been effectively employed in games such as the online Depict1, a side-scroller in which the directions of a narrator are almost always lies and often lead to the player's death [89], and The Stanley Parable [24], an interactive narrative in which the player navigates to ongoing narration that he may sometimes choose to disobey, aggravating the narrator. With respect to narrative cognition, narrative voice is of most clear importance in the task of comprehending narratives and rhetorical situations as negotiated with others.

2.2.4 Summary

We have considered the question of the structure and nature of narrative from the literary and dramatic disciplines and have sampled a small portion of the theoretical concepts that these fields have produced. From the dramatic fields we receive structures exhibiting pragmatic modularity, which is well-suited for narrative generation, and philosophical paradigms establishing groundwork for work in natural and cognitive narrative.

Western literary theorists have made inextricable contributions to modern concepts of narrative across media. The micro-analytics of Barthes provide a framework for analyzing the atomic details of a narrative object, with emphasis upon the effect of a narrative upon the reader. Genette's higher-level approach provides notions of narrative are generalizable and important to modern narrative forms, speaking to properties of narrative that are largely independent of the media in which a narrative is embodied.

The structural emphasis on cohesion, Genette's work on mood, voice, and narrative-narratee relations, and the drama- and plot-centered approaches to narrative each lend support to a notion of narrative quality that can be seen as sharing a measure with Fisher's narrative rationality, centering on validity to the receiver and internal coherence.

2.3 Cognitive Narrative and Natural Narrative

The structuralist narratology that has been considered previously is concerned with narrative universals and is concerned with narrative as an object or as a category of objects that can be rigorously analyzed. This approach is a natural extension of critical thought from literary, dramatic, and film fields, which take as the primary objects of their study exemplars developed by (usually) non-scholar authors, producers, directors, and playwrights. Marie-Laure Ryan observes the dispersion that has occurred to broaden the critical relevance of narrative, pointing out that in recent years "the narrative turn in the humanities gave way to the narrative turn everywhere (politics, science studies, law, medicine, and last, but not least, cognitive science)" [117]. This turn has led to two major theoretical responses to the breadth of narrative relevance articulated by Ryan: the study of narrative across differing media and the study of narrative as a cognitive thing transcending, or possessing a more fundamental nature, than its mediated forms. The distinction between these two approaches echoes the distinction between Genette's narrative or storytelling, which implies mediation, and story, which refers to the underlying structure which is eventually filtered and transformed into a told narrative. However, it is important that this distinction between the story and the storytelling not be dogmatized; particularly in the realm of cognition the distinction between story comprehension and story generation–that is, the difference between a story being crafted outside or within one's mind–is a blurry one.

There is an important distinction between the cognitive narrative discussed in this section and the contents of chapter 3, which is concerned with certain psychological mechanisms that have purposes including support for cognitive narrative. The contents of this section remain centered upon narrative itself, considering the mind through a narrative lens. In undertaking this discussion it is useful to draw a distinction between *natural narrative* and *formal narrative*, analogous to the distinction between natural languages (those learned by children and spoken by humans) and formal languages (those composed, such as computer programming languages). Formal narratives are the object of the afore-mentioned critical approaches that focus upon analysis of (published) artefacts. Natural narratives are the central concern of this thesis and bear the closest relationship to unmediated (cognitive) narratives. In handling these increasingly dynamic notions of narrative new ways of defining the subject–or avoiding defining–have been developed.

2.3.1 Cognitivist Approaches

In *Towards a Definition of Narrative* [117] Ryan summarizes definitions of narrative from a variety of scholars and disciplinary backgrounds. Among the more recent trends in narrative theory is that of cognitive narrative, which views stories as a cognitive structure that transcends the particulars of semiotics and mediated texts. One of most influential voices on the subject is that of Jerome Bruner, who argues for narrative as a key tool by which humans create reality [17]. He lays out a set of ten narrative features which, though similar to catalogs of traditional features from narratology previously discussed (i.e. with Barthes and Genette), is concerned not with "how narrative as text is constructed, but rather how it operates as an instrument of mind in the construction of reality." In spirit Bruner's approach is akin to Schank and Abelson's work on cognitive systems in which stories and narrative structures such as scripts are regarded as fundamental mechanisms of thought [120]. Two of Bruner's narrative features are particularly relevant to us.

One of Bruner's most significant observations on the features of narrative cognition is made by highlighting the function of canonicity and breach. In contrast with Schank and Abelson's scripts, Bruner argues that narrative centrally comprises breaches of expectation while, naturally, maintaining an reckoning of the expectations themselves. In Bruner's approach, the boring are not narratives at all, and any narrative will feature breach.

A second and related feature from Bruner's list is normativeness, which is the concern by which expectations are maintained. Herman extends the maintenance of norms by taking the creation of norms as a key function of narrative cognition [47]: a culture's remembered and re-told stories help to establish the societal norms by which social acceptability is reckoned. Bruner applies this function of narrative as an inherent concern with episteme or knowledge of truth; reiterating Burke's dramatism, Bruner suggests that cognitive narrative fundamentally deals with suspense and uncertainty.

Ryan points out that Bruner's approach to cognitive narrative applies only to narratives for entertainment, failing to recognize narratives of news, history, or daily conversation. Scholars such as Brewer ("Stories are to entertain" [16]) were arguing this case decades before Bruner's elaboration of narrative reality, proposing an affective framework for understanding narrative; but these notions are incompatible with cognitivist approaches to narrative that regard narrative as being a central constituent of human thought, which after all concerns much more than entertainment.

Ryan makes a more serious criticism of cognitive narrative. She rightly points out that over-eager appeals to the mental omnipresence of narrative run the risk of conflating narrative with thought itself. A similar argument is made at length by Galen Strawson [123] and other objectors, who particularly object to narrativity as a core constituent of personal identity (an debate which has raged [18, 123, 32]). It is clear that any serious approach to cognitive narrative needs to deal with the boundaries and limitations of narrative as either distinct from or synonymous with other faculties of cognition.

2.3.2 Narrativity

The move toward cognitivist approaches to narrative is a natural evolution from semiotic approaches like those of Barthes and the life-as-narrative paradigms of dramatic descent, like Fisher's narrative paradigm. As focus has shifted to phenomenological concerns scholars have departed from binary definitions of narrative or static ideas of narrative structure. The idea of narrativity was early articulated by Marie-Laure Ryan [117] and set a trend for thought on narrativity as a graded quality, rather than a simple yes-no value. According to Ryan's rubric, narrative fluctuates to differing degrees of adherence to requirements in four dimensions (table 3). The goal of these dimensions, which owe clear inspiration to Genette's characterizations of narrative

Table 3: Ryan's "fuzzy-set" dimensions of narrativity [117]

Spatial	1	Narrative must be about a world populated by individuated existents.
Temporal	2	This world must be situated in time and undergo significant transformations.
	3	The transformations must be caused by non-habitual physical events.
Mental	4	Some of the participants in the events must be intelligent agents who have a mental life and react emotionally to the states of the world.
	5	Some of the events must be purposeful actions by these agents.
Formal and Pragmatic	6	The sequence of events must form a unified causal chain and lead to closure.
	7	The occurrence of at least some of the events must be asserted as fact for the story world.
	8	The story must communicate something meaningful by these agents.

qualities, stands in contrast to structuralist approaches and aims to provide users with a means for generating their own definitions of narrative according to which dimensions or requirements they deem to be of most import for their work.

Ryan follows her outlaying of these dimensions with a careful enumeration of the text-types that can be excluded as typical narratives by application of these rules; for example, condition 1 can be adhered to in order to eliminate from a definition of narrative general abstractions or stories about the human race, the universe, the brain, etc; or condition 6 can be prioritized to eliminate hyper-realistic descriptions, the majority of raw security tape footage, or ongoing diaries or logs. Ryan's intention is to provide a tool-kit for creation of definitions of narrative; whether or not a scholar chooses strict adherence to Ryan's eight narrative dimensions, the principle of providing and defining dimensions of narrativity is particularly useful as narratives begin to find new forms in media that challenge concepts of traditional narrative structures.

2.3.3 Natural Narrative

In this thesis the term "natural narrative" has been chosen by analogy to the linguistic ideas of natural and formal languages, emphasizing the cognitive and human basis of narrative that is our concern; it is also precedented by Fludernik's *Towards a Natural Narratology* [37]. In other literature natural narrative is referred to as personal narrative, conversational narrative, or, as in the title of Ochs' and Capps' book, *Living Narrative* [100]. With all of these terms the subject is narrative that is informal, emergent, and negotiated or discursive.

Natural narrative stands apart from the carefully crafted narratives generally considered by the traditional critical arts. To some degree natural narratives are the embodied expression of ideas from the cognitive approach; the storytelling of everyday activity is a vivid witness of the functionality of narratives in our daily lives, as well as of the uses to which we put narrative.

The inaugural study of what we are here calling natural narratives was conducted by Labov and Waletzky [57] and is oft cited in the closely-related discourse analysis literature. In their studies Labov and Waletzky interviewed citizens and gathered their personal narratives, forming the basis for much future work in discourse analysis, linguistics, and narratology. Labov's work set a precedent for later work of scholars like Monica Fludernik who considered the study of narratives in their natural, personal, lived state to be fundamental to an understanding of more sophisticated narratives that are the subject of literary analysis. Labov's work has been influential for the development of narrative interview methodologies as well as for the formal analysis of recorded oral narratives [101].

Fludernik's work has been oriented around the concept of natural or personal narrative as a "prototypical form of narrative" [37, 38]. Ochs and Capps illustrated this idea with an analogy from archaeology:

> We are reminded of the work of Nicholas Toth, who revolutionized the understanding of Stone Age tools. Prior to Toth's studies, the received perspective was that early hominids chipped a cobble in such a way that it could be used as a pick or hand ax. Researchers considered the splintered flakes as waste products and examined them for information about techniques used to shape the stone core tool. While others were analyzing the morphological shapes and cognitive correlates of the chipped cores, Toth, in a radical turnabout, discovered that the flakes were the primary tools and that the large stone was an incidental by-product, possibly a secondary tool. The flakes turned out to be ”extremely effective cutting tools” for animals, wood, hides, and other work. . . . we posit that like stone flakes, mundane conversational narratives of personal experience constitute the prototype of narrative activity rather than the flawed byproduct of more artful and planned narrative discourse. [100, p. 3]

These notions of the essentiality of natural narrative are supported by literary philosopher Mikhail Bakhtin, who argued that "the true essence of a text always develops on the boundary between two consciousnesses, two subjects" [7, p. 106]. One impact of these ideas, which has effected both cognitive and literary approaches to narrative has been the idea of development within narrative. From an artefact-analytic perspective this has led to the idea of narrativity, by which the question is no longer the categorization of something as being a narrative or not (a favorite endeavor of modernism), but the understanding of artifacts as falling on a gradient of more or less narrativity, a structure that is more useful to ideas of narrative as a cognitive object than the former dichotomy. The assessed narrativity, in turn, can express the degree to which narrative cognitive functions suited to application of or upon a given text (natural or artificial).

A second concept pointed out by natural narrative and Bakhtin's argument is the developmental or emergent nature of narrative–that both individual narratives and narrative as a tool of the mind develop over time. Ochs and Capps explore these two developments in parallel, considering the development of narrative abilities within young children as well as the discursive development of narratives for moralizing and sense-making [100, 125].

2.3.4 Narrative Intelligence & Instrumentality

We use narrative as a tool with which we make sense of and negotiate reality, as has been discussed with natural narrative. While the heritage of studies by Labov, Fludernik, and others utilize methods of discourse analysis and analyze recordings and transcripts of told stories, these stories also reveal key characteristics of the mind. In the context of oral cultures and the formal oral narratives produced by them, David Rubin has rigorously considered the mnemonic structures used to remember sizable ballads, stories, and epic poems [115]. For many of these cultures, storytelling is a crucial form of their traditions, education, and, to the gratification of arguments like Bruner's, their world-making practices. There is promising further research to be done from a cognitivist approach to the features of formal yet non-literary narratives, which look to be a middle-ground between the strata of natural and traditionally considered formal narratives.

Some of the cultures considered by Rubin could be excellent candidates for further research into cognitive narrative functions unclouded by the prevalence of modern first-world broadcast/streaming media. In particular a set of cognitive functions of narrative have been proposed by literary/cognitive narratology David Herman, who describes five problem-solving functions that narratives fill in the human mind [47, 50], visible in table 4.

Activity 1 from Herman's listing involves world sense-making, which Herman has

Table 4: Herman's five problem-solving activities supported by narrative [47]

1	"Chunking" experience into workable segments
2	Imputing causal relations between events
3	Managing problems with the "typification" of phenomena
4	Sequencing behaviors
5	Distributing intelligence across groups

elsewhere considered at significant length [48] and which may need to occur before the other supporting activities are achieved. Like Bruner's concept of narrative reality-making, Herman observes the way in which narrative structures (similar to Minsky's frames from cognitive science/AI [88]) are used to divide the stream of experience into segments that are "bounded, classifiable, and thus more readily recognized and remembered." This capability is called by Mateas and Sengers **narrative intelligence** [84], the ability to consider experience in narrative terms. The development of an experiential story-base provides the foundational resources necessary for use by the other functions and by advanced forms of narrative cognition, even before children have the experience or capacity to exhibit more advanced forms of narrative cognition or storytelling ability (see [100, ch. 2]).

The second supporting function of narrative is likewise important to learning. Despite the statistical truism that correlation does not imply causation, imputing before-and-after causative effects is a crucial developmental heuristic for us, and a key (if sometimes fallible) mechanism in learning. The fundamentally sequential ordering of natural narratives and experience means that narrative exploits and relies upon cause-and-effect logic; inversely, insomuch as graded narrativity is admitted, sequences without recognizable cause-and-effect demonstrate less narrativity and are, ostensibly, less cognitively salient.

Activity 3 from Herman's list, concerning typification, is similar to Bruner's point about narratives being concerned with norms [17]. Herman observes that in essence we use narratives to structure the daily experiences of life and manage our attention by defining what's normal and what's surprising. It is worth noting that this occurs at a range of different scales, from moment-to-moment activities to general behaviors, any of which can be associated with narratives that provide predictive power. Herman also points out that stories can be told preceding or without actual breaches, in which case they can either make visible distinct differences in situations or provide a comparison for breaches of expectation by which problem-solving tools like analogy might be brought to bear.

Activity 4 refers to more than the major cognitive function of planning, which is well developed in AI and cognitive science [137]. Herman points out two distinct means by which storytelling supports sequencing. The first is as a social tool by which turn-taking behavior is relegated in direct communication. On any of the scales between the story teller's "taking of the floor" (consider in connection with the dramatist perspective on people as actors, section 2.2.1) to the back-and-forth of conversational story-making, narrative has traditionally and naturally made heavy use of turn-taking and sequencing. On the other hand, the structure of narratives themselves and the means by which narratives express story worlds reflect a sequence-sensitive nature, as is a running theme through Genette's analysis of narrative structure (section 2.2.3.2). This structure may not be naturally occurring in some aspects of the world, particularly as we are involved in increasingly abstract social or temporal realities, and in such cases narrative can support orientation and management of abstract levels of experience.

Finally, Herman's fifth item emphasizes the social nature shared by both narrative and intelligence. Invoking the concept of distributed cognition by which intelligence is increased by cooperative diffusion, Herman argues that narrative is "at once a vehicle for and target of such distributed cognition." This can be taken in connection with Mar and Oatley's strong assertion that "the function of fiction is the abstraction and simulation of social experience" [81] to highlight the role of narrative as a necessary tool for effective sociality.

Taken together Herman's five functions of narrative cognition can be seen as targets of aspiration for cognitive systems. The promise of such capacities would be significant reward for AI developers, while the mechanisms and improvement of these abilities are of interest to cognitive scientists. Finally, designers of narrative experiences can also be well served by building to the narrative capacities of their audiences.

2.4 Computational Narrative

Computational approaches to narrative have opened new paths of study along with new types of stories and new methods of storytelling. In general most of the approaches in computational narrative can be considered as falling into one of two major categories: those oriented around narrative comprehension, including summarization and learning systems; and those oriented around narrative generation, including story-writing systems and interactive game systems. The computational approach to narrative serves the function of bridging traditional humanities and social narrative studies with artificial intelligence, which also adds supporting resources for cognitive narrative research. In both cases computational narrative has benefited from narratological theory, particularly structuralist approaches which tend to provide computationally friendly formalisms.

Both narrative comprehension and generation possess a similarity from functional perspectives: they both produce narratives. A distinction is in what they take as input: comprehension systems take narratives as input, while generation systems may take narrative fragments, plans, action libraries, or other non-narrative components.

2.4.1 Narrative Comprehension

Although homage has been paid to the foundational nature of Propp's contributions to computational work on narrative, much of computer science's first work on narrative was brought about by motivations apart from the contributions of Propp, arriving instead from a path in computational linguistics. Realizing that any competent language-using computer would need far more than grammatical understanding, but in actuality a capacity for semantic context and general knowledge, computer scientists and cognitive theorists brought their attention to narrative. One of their foremost contributions to the thought on cognition and narrative was the articulation of Schank and Abelson's concept of scripts [120] and concern for knowledge structures that could either derive from or parse narratives [15, 14].

In many ways scripts resemble the plots emphasized by dramatic approaches, constituting an abstracted, ordered list of actions or events. In principle a script represents a generalized sequence of "usual" events for a given scenario, such as going to a movie or eating at a restaurant. Work on generating scripts by parsing stories has been done by Li [73, 74, 72], who used Amazon Mechanical Turk [55] to crowdsource knowledge of typical stories, such as bank robbery or going to a movie, and then performed natural language processing over the crowd-provided results to generate plot graphs from the data.

Provided knowledge of scripts, another key facility is the recognition of scripts that are taking place–not only deciding upon a script for generation purposes, but situating the self within an ongoing script. Such functions as this begin to move beyond any audience-centricity of dramatic approaches to narrative and are concerned more with application of narrative for intelligence, a process with promise for computers and evidence as a human capability.

Another major application of story comprehension systems has been summarization [70]. This is applied to news stories, for instance [28], where the goal is to bring to users a concise compilation of long or ongoing stories and to help information analysts cope with an increasing flood of global event information. An summary of recent work in this area is from Van Erp, Fokkens, and Vossen [133], who outline guidelines for approaching the multi-genre content of news stories and suggest that strainers (higher-level abstractions of narratives) are “the most compact and informative structures for representing the essence of large volumes of news data over longer periods of time.”

Narrative comprehension represents one of the most important areas for future work in cognitive narrative insomuch as it would facilitate the core narrative function of communication, as pointed out in Herman’s fifth item of story instrumentality (table 4) on communication and distributed intelligence. It is also a key faculty for learning and improvement of cognitive narrative.

2.4.2 Narrative Generation

In addition to scripts Schank and Abelson’s also brought to the discussion the concepts of plans and goals, which have been found to lend themselves well as tools for computational narrative generation. Both of these concepts are fundamentally based upon the idea of *states*: factual (often mathematical) descriptions of a situation at a given time. A state could represent almost anything; in a game of chess, each position of the board before or after a move is a state. In a narrative, each situation or scene can be a state. A goal is some property or set of properties that is desired in the states (e.g. Romeo being married to Juliet); a plan consists of states threaded together from beginning until goal, joined by *actions* or events that transition one state into the next. While Schank and Abelson may never have achieved their desired height of general intelligence in a computer system, planning has become an enormously successful field of research in its own right.

Researchers have found plans to be convenient forms to represent fabulas, which can then be derived into sjuzhet and text expression. This trifold approach to narrative generation has led to one of the leading schools of thought in narrative generation (with a broad summary available in [110]). Using this approach researchers such as

Mark Riedl have cast the story generation problem as one of balancing character believability and plot coherence [112], a point echoing the driving tension observed in natural narrative by Ochs and Capps "between narrators' yearning for coherence of life experience and their yearning for authenticity" [100, p. 24].

One of the earliest story generation systems is *Tale Spin* (1977, [86]), which preceded modern planning formalisms but considered narrative generation as a process of problem solving, generating tales of woodland creatures based on goal achievement. *Universe* (1983, [68])chose soap opera dialog/script generation as its genre, and placed explicit emphasis on relatively complex character representation; it produced plot lines with no concrete ending (stories that could continue indefinitely). *Minstrel* (1993, [131]) told moralistic stories about King Arthur and the knights of Camelot; it used goals and plans to generate a story that satisfied author-level goals. *The Oz Project* [76, 11, 75, 83] was an ongoing effort that approached story generation as primarily a process of character simulation, again using a form of planning; because independent agents would act in discord without generating a recognizable story, a drama manager was created to give over-arching guidance. The use of a guiding drama manager has been used in a number of systems since then.

Useful, deeper surveys of narrative generation approaches are available in the work of Riedl [112], Harrell [46], and most recently Gervás [41].

As video games have grown in popularity there is a keen interest in story generation systems that can react to the activities of the players or lessen the need for handcrafted narratives in worlds that might include hundreds of thousands of players (Massive Multiplayer Online games such as World of Warcraft). While work is still too young to introduce systems that can satisfyingly scale to the level of MMORPG games, this is a burgeoning field of research. Two interactive narrative systems will be considered as examples. *Facade* [85] is a game which, through careful and costly handcrafting, produces rich and nuanced variations on a narrative that affords constrained agency to the player; and *Haunt 2* [78] utilizes an Interactive Drama Architecture [79] to maximize player agency while generating simpler, but still complete, stories.

Mateas and Stern's *Facade* labels itself as an interactive narrative, rather than a game, and sets the reader within a dinner party with a couple which, as dialog continues and play unfolds, is seen to be on the verge of divorce. Players interact via typed dialog and the game generates goals for the virtual characters that take into account the player input. A planner was used to generate the activities of the couple, with "beats" used to measure a small snippet of dialog that constitutes the verbal actions by which a plan is executed. Ultimately the player either witnesses the ending of the couple's relationship or sees it repaired.

Facade produces rich, nuanced stories, but at the expense of carefully scripting. Because of its reliance on hand-written material there was a lower-bound limit to the range of unique plot-lines that could be generated by distinct player actions. Balancing hand-authored content with player agency and generative freedom is a major point of oscillation in interactive story generation systems. An example from the opposite side of the spectrum is Magerko and Laird's Interactive Drama Architecture, showcased in *Haunt 2*. Built on the Unreal game engine and the Soar cognitive architecture, *Haunt 2* was designed to allow players a maximum of freedom while still producing complete stories. It did this by taking an author-generated story which is issued to the AI story director, which orchestrates the activities of the non-player characters in the game and performs prediction upon player activities to assess endangerment of the plot, adapting the world if necessary to keep the plot on-track. The story itself is set within a bed and breakfast in which the player haunts the site as the ghost of a murder victim, aiming to discover who the murderer is and interacting with the world, and invisibly with characters in the world, to solve the crime.

2.4.3 Summary

Work in computational narrative on narrative comprehension methods is similar in spirit to analytic approaches from the humanities, and as a knowledge-engineering and machine-learning endeavor has a relationship to cognitive approaches to narrative as well. Work on narrative generation is burgeoning now with interest from video game and entertainment industries and is more distinctly influenced by pragmatic approaches in structuralism and production-oriented dramatic approaches. Narrative generation also reshapes story telling to employ the affordances of digital media, although many current systems seem primarily focused upon generation of story structure rather than a surface-form text (media).

The theory for cognitive narrative introduced in chapter 4 has similarity to simulation-based approaches to narrative generation (including the emphasis on simulated characters in *Haunt 2*). Though current narrative generation approaches do not tend to consider narrative from a cognitivist perspective, the story-understanding of the comprehension work and the mechanisms of the generation work are both of use to research in cognitive narrative in theory and in AI.

2.5 Conclusion

This chapter has considered a broad variety of approaches in narrative, but the survey is far from exhaustive. A complete survey within any single one of the highlighted fields would require volumes, if it were possible at all, and with continual advances in media, technology, and narrative theory, any exhaustive approach would be rapidly out-moded. This survey is, however, one of unusual breadth in considering the range of fields that it has, a fact that is complemented by the elaboration of certain psychological literature in support of narrative theories in chapter 3. The fields that have been considered in this chapter each provide valuable insights.

The dramatic approaches to narrative elaborate some of the roots of narrative study, revealing an original closeness between narrative and human life and activity that is sometimes distanced in the complex literary narratives that later seized narrative studies. However, dramatic approaches have continued alive and well, and have produced, besides their original contributions on narrative structure, narrative philosophies for society and personal life. Of particular value is Fisher's definition of narrative rationality, which generalizes a means of narrative evaluation that is relevant to cognitive narrative and natural narrative.

The broadest and deepest research into narrative stems from the literary arts, from whence the field of narratology itself originates. Literary scholars, critics, and philosophers have delved deeply into the study of narrative objects and have produced a wealth of insights. The choice to focus on Barthes and Genette here, both of whom constrained their principal studies to a narrow selection of narratives, was made due to the foundational nature of their approaches to narratology, with later work proceeding largely in genesis from the work of these two. Barthes particularly considers the surface, semiotic and meaning-making level of narrative, occupied at the level of what Genette would call the narrative and narrating levels. Barthes work highlights the phenomenology of narrative, a principle of pertinence to cognitive narrative and the theory of narrative cognition we will lay out. Genette's work, conversely, focused on the structure of narrative in general and laid groundwork for later structural analysis and support for Propp's related structural approaches. Genette's work on the structure of narrative does indeed generalize nicely to a breadth of the narrative spectrum, as is evidenced by its use as the basis of narrative structuralism.

Cognitive narrative is the central concern of this thesis and owes its heritage to both the literary and the dramatic perspectives. Central to this thesis is the concept of natural narrative, the stories we use for reality-making and identity-making. The theory of cognitive narrative brings to bear the centrality of the human condition to narrative by definition, and inversely, the centrality of narrative to the human experience. It also suggests an origin for narrative distinct from the historical origin for narrative studies from the dramatic arts: narrative can be considered as originally, fundamentally, a cognitive thing. With this vantage it can be seen that the "deep structure" of narrative is not precisely Propp's fabula or Genette's story, both of which are literary tools without making claims about cognition, but something that fills that roll within the mind, awaiting further study which the theory of this thesis hopes to hone in on. Also of notable worth from the cognitivist approaches to narrative is Herman's enumeration of the ways in which storytelling or narrative is instrumental to the human mind, which provides a guiding path for future exploration once fundamental narrative cognition is modeled.

The computational approaches to narrative make a number of distinct contributions to narrative theory and the work of this thesis. One of the primary purposes is the implementation of theories: narrative comprehension offers a testing-ground for some ideas from cognitivist approaches and theory on readership, while generative approaches clearly take into account structuralism. In so doing a new sort of artifact is produced; narratives of this new generation can be compared to the narratives upon which the literary theories performed analysis in order to evaluate the the points of greatest efficacy in the theories.

A final major contribution from the computational approaches is that they serve to bridge the fields of computer science and narrative theory, offering a place for cross-pollination and a range of insights from both fields. The results are in supporting work like the theory in later chapters of this thesis, while also providing valuable resources to the cognitivist case that narrative can be directly meaningful for cognition, if within artificial intelligence then perhaps also in human cognition.

CHAPTER III

MEMORY AND EVENTS IN NARRATIVE

The purpose of this chapter is to introduce key mechanisms of the human mind that support narrative cognition and inform our understanding of how cognitive narrative works. As narrative cognition is inextricably involved with human memory, particularly the episodic and semantic long-term memory systems, first are considered the memory systems that provide for narrative activity. Narrative influence has also been demonstrated on short-term memory mechanisms, particularly perception. Together these considerations help to gain an understanding of the overall relationship between narrative and the human mind–the means by which narratives are a component of our every-day intelligence as well as a portal into the mind.

This chapter begins by looking at the long term memory systems. Semantic memory is considered in section 3.1; while the typical contents of semantic memory seem distinctively non-narrative in form, they have direct impact upon the narrative processes. Episodic memory is the subject of section 3.2 and is of central concern to us as the storage place for life experiences, autobiographical memory, and even future or vicarious experiences.

Finally, in section 3.3 we introduce Jeffrey Zacks' Event Segmentation Theory (EST), a theory of perception that suggests the means by which we perceive events in the world around us. This perception is directly influenced by the contents of semantic memory and produces events that become part of the contents of episodic memory; crucially, these events are also the basis for personal narratives. EST is supported by evidence that includes narrative comprehension and forms part of the theoretical basis of the approach to narrative cognition that is presented in chapter 4.

3.1 Semantic Memory

Semantic memory is the storage place for general information like facts and structures. It is the system in human memory that most resembles the physical memory of today's computers, storing something like "random access" facts, memorized lists, or the long-term principles that are digested and eventually separated from read or experienced narratives. The term "semantic memory" was born at the same time as episodic memory, originating to distinguish these systems from the over-arching declarative memory [129].

Although semantic memory is not primarily narratively structured, narrative cognition cannot proceed without its contributions any more than literary narratives can exist without non-narrative components such as descriptions. Semantic memory provides the substance and architecture of story worlds, particularly in the form of scripts and schema. A major product of cognitive scientists Schank and Abelson's work on narrative comprehension in the 70's and 80's [120, 1], scripts describe the usual order of actions within common activities, such as going to a restaurant or a movie. Similarly, semantic memory is heavily at work in the highly patterned narratives of oral cultures [115]; for example, the order in which the descriptors of oceans, navies, and armaments are laid out in Homeric Greek epic.

Scripts, which are principally concerned with actions, can be considered a subset of Bartlett's *schema* [10]. Schema, which have been effectively cannonized into theories of psychology by the work of researchers like Piaget and Rummelhart, are particularly pertinent to conventional understanding of narrative as genres, which provide the repertoire of concepts, tropes, and themes from which a narrative may draw. Bartlett's original work included narrative experiments in which subjects were asked to recall a novel narrative from a foreign culture; relying upon their culturally acquired schema for narratives, subjects were found to adjust their recollection of the narratives to accomodate the schema with which they were familiar. These results

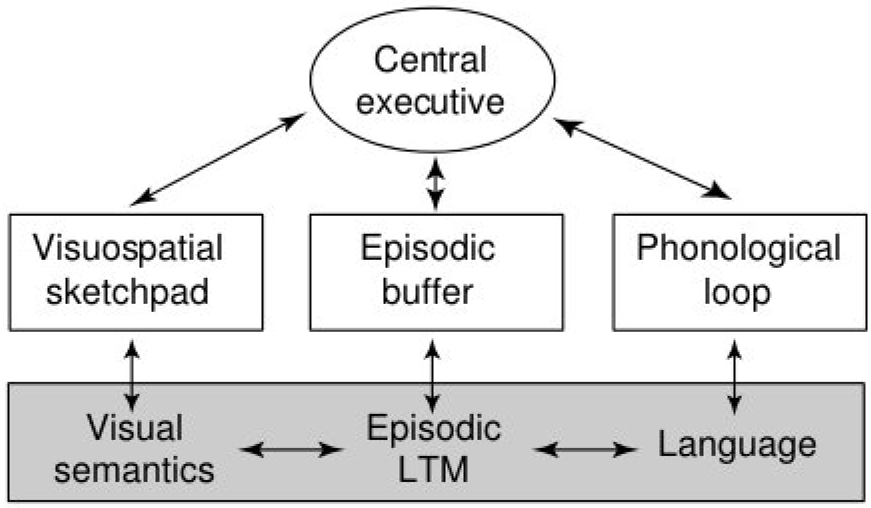

Figure 4: Baddeley's revised working memory model, including the episodic buffer [4]

have had deep implications for our understanding of how human memory works and, indeed, for crucial differences between creative, malleable human memory and the verbatim memory of computers.

Semantic memory supplies the scripts, schemas, and genres by which top-down processes influence narrative cognition [120] [108], and so plays a vital role in mature narrative intelligence. Evidence from developing narrative intelligence within children suggests that the acquisition of these narrative structures within semantic memory is one of the significant forms of progress as children grow [135] [100, ch. 2]. However, the same evidence indicates that however poor, some degree of narrative ability precedes the significant acquisition of semantic narrative structures and that one of the functions of increasing experience is the construction of the scripts and schema that will allow for improved top-down contributions to narrative intelligence. Narrative intelligence, then, may begin with episodic memory before being augmented with contributions from semantic memory.

3.2 Episodic Memory

Episodic memory was introduced into the main body of psychology theory by Endel Tulving's seminal "Organization of Memory" [129]. Semantic memory has long been understood to be our primary memory system and the target of most traditional forms of education. It is the store for isolated facts, from geographic capitols to mathematical formulae to word definitions. The contribution of Tulving's innovation was to suggest that the human experience consists of much more than isolated facts but is, in fact, characterized by events that occur in a temporal context and are interconnected over time and by the flow of cause-and-effect and can be empirically differentiated from eachother. Tulving's 1986 paper on the distinction between episodic and semantic memory [130] demonstrates a response to the sort of challenges that initially opposed his addition to the vocabulary of memory psychology. Initial critics viewed episodic memory as an unnecessary complication of the memory model, a subset of semantic memory that muddied the waters without bringing any useful additions to the table. Gradually these concerns were laid to rest as both illnesses and memory functions came to corroborate the reality of episodic memory.

As the theory of episodic memory grew in credence it soon interacted with what continues today as one of the major short-term memory models, Baddeley' and Hitch's multi-component working memory model [5]. This memory model represents working memory, the short term memory employed in human awareness and cognition, and originally accounted only for sensory input conforming to the visuospatial sketchpad and phonetic loop. The model leaves up to interpretation the interaction with various models of long-term memory, initially causing it to seem segregated from any long term system like episodic memory. This division has proven untenable, however. Modern research has prompted Baddeley to extend his original model. He proposed the addition of an episodic buffer (visible in the middle of figure 4) to offer an explanation for the binding problem (whereby diverse stimuli are perceived as a coherent whole), resistance to expected problems involving rehearsal suppression in the phonological loop, and situations in which those with severe amnesia were able to exceed phonological loop limits for prose-text recall by exhibiting “chunking,” a process largely associated with long term memory (see [4]). This episodic buffer was proposed for use in short-term memory complementary to the conventionally understood episodic long-term memory [4]. The role of Baddeley's short-term episodic buffer is as a holding area for retrieved episodes to be integrated cross-modally with data from other sources, such as perception or semantic processing. From a narrative perspective, this may be where stories are constructed through blending with other elements in working and semantic memory, and may be where narratives are manipulated for functions of narrative cognition such as those suggested by David Herman [47].

Episodic memory is the system responsible for storage of both personal experiences and any other time-situated events attended to second-hand, for example through media or personally communicated stories [51]. It is also implicated for prospective memory used to consider the future [118, 119, 106], supporting Tulving's original description of episodic memory as being for “mental time travel.” In the last two decades a flurry of research has been directed at episodic memory; particularly relevant to narrative studies is the distinction of an episodic sub-system at work in autobiographical memory, a distinction supported by the psychological data [94, 71, 132] and distinguished from non-autonoetic memories that do not include personal awareness or presence as part of the substance of the memory [103].

3.3 Event Segmentation Theory

Event Segmentation Theory (EST, figure 5) [139, 56, 108] is a theory of perception that incorporates long term and short term memory. In humans, event segmentation is an ongoing process occurring simultaneously at multiple time/action granularities.

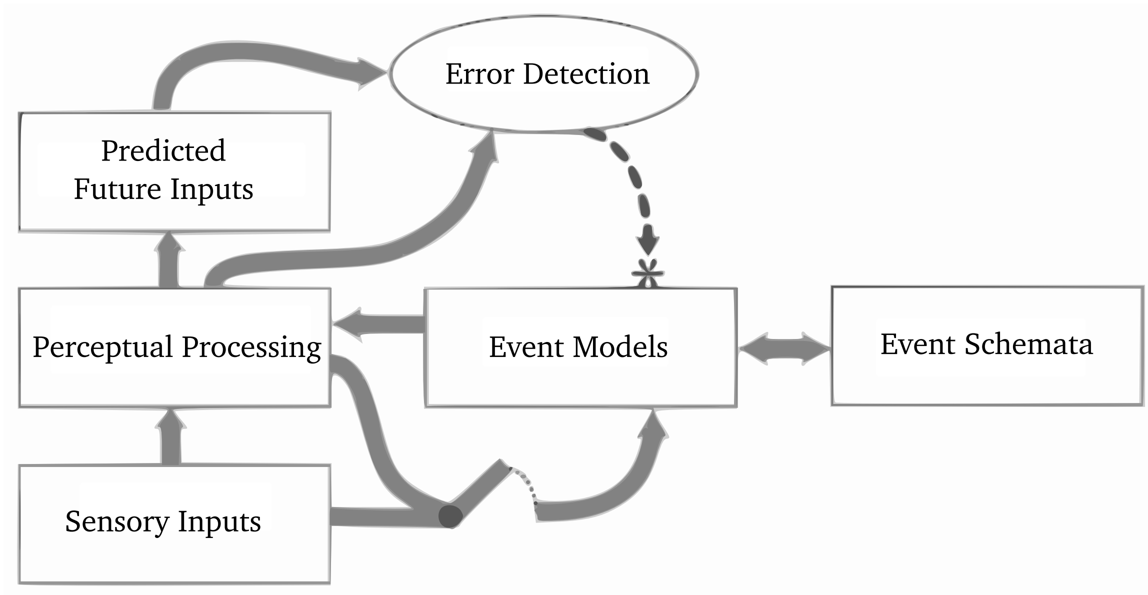

Figure 5: A high-level view of EST, image from [139]. Information flows along gray arrows and error detection leads to resetting of event models, which is the only time sensory input is gated to them.

It bears in common with other perceptual theories the assumption of three closely related characteristics:

1. Hierarchy
2. Recurrence
3. Cyclicality

These three features and their relevance not only to perception but to our theory of cognitive narrative will be considered in turn.

The hierarchicality of perception comes into play in the fact that perception occurs at multiple levels of granularity; for example, the presence of a fly swatter, the movement of a fly swatter, the recognition of a guiding hand, and so forth. A different example is hierarchical ordering for orientation, whereby the orientation of an object is determined after considering its relation to its surroundings [122]. In each of these cases perception is hierarchical insomuch as there is perception of components and subordinate/superordinate relationships, or there are subordinate relationships in the types of perception that occurs. This characteristic of perception is evidenced in the successive transformation of representations. The characteristic of hierarchicality also has a bearing on narratives, which have as a fundamental characteristic the ability to be composed into larger (higher-level) narrative structures, as occurs with narrative summarization [80] or with meta-narratives [18, 45].

Recurrence within perception refers to the fact that later stages of perception (such as prediction) can effect earlier stages of perception (as they occur in future cycles). In perception this is evident when the presence or absence of an object is overlooked by observers of a scene until realization of the greater context occurs. With narrative recurrence is related to the delibarative, iterative nature that is observed with the development natural narratives, particularly when they are negotiated with collaborators [100, ch. 1].

Finally, cyclicality refers to the continuous, ongoing processes of perception, the same which are repeated in illustration of recurrence. Further, perceptual predictions are constantly compared to actual perception and the results guide ongoing perception. This, we suggest, constitutes a significant difference between perception and narrative intelligence or the narrative generation that occurs in cognition; as a complex, deliberate process, cognitive narrative generation is not continuous, as suggested by the role of episodic memory and the reflective processes often used, betwixt gaps in other activities, to perform narrative sense-making of past experiences or creation of future expectations (as with the toddler's personal storytelling of both past and future in the crib by night [100, ch. 2]). This is not to suggest, however, that narrative cognition does not effect perception, as EST plainly indicates in the use of event models and schema, below. According to EST, event segmentation occurs as an effect of ongoing perceptual prediction. During the process of perception two structures are the primary participatants in parsing the situation and forming predictions: long-term knowledge is brought to bear in the form of event schemata, which are similar to Schanks' and Abelson's scripts [120] and represent the way actions or events normally unfold in similar situations; and working-memory is brought to bear by event models, which are an interpretation of the specific situation at hand. In addition, behavioral models may be used so that predictions can be made based on the presumed goals of the actors in a situation, and world models that account for physical expectations (e.g. the trajectory of an object in free motion). The interplay between the semantic and episodic long-term memory systems in this process is cyclical: semantic memory provides the structures and models to help make episodes from experience, while these episodes are committed to episodic memory where, over time, they help distill further knowledge of semantic structures.

As perception occurs, the mind selects from its knowledge of usual event schemas and uses assumptions about the goals and processes at work in the attended situation to generate expectations of what will happen next. As long as these predictions are mostly fulfilled, the current event model is assumed to continue and no segmentation occurs. However, when the predictions are wrong by some margin of significance, the current event is considered to end and a new event begin in the process of selecting or generating a new event model. These explanations of event segmentation have been supported by evidence from studies of segmentation of event boundaries in written and video narratives [139]. Narratives are constructed as segmentation occurs at broader granularities over episodic memory, to the point of eventually contributing to production of the life-long autobiographical memories that "make up our own personal narrative of who we are and what we have experienced" [108, ch. 8].

CHAPTER IV

A THEORY OF NARRATIVE COGNITION

Previous chapters have discussed narrative theory and psychology supporting narrative cognition. Narrative cognition seems to be an essential component of human thought and is instrumental in the way that we interact, are entertained, express ourselves, and make sense of life. It is also a capability mostly foreign to artificial intelligence that could open vast possibilities if implemented in systems that interact with us and produce for us, whether they are performing (as with expressive AI), playing (video games), or collaborating (artistically, for utility, or in team-based activities). In this chapter we detail an approach to implementing basic cognitive narrative by applying Event Segmentation Theory within the Soar cognitive architecture. We begin by introducing cognitive architectures and their narrative-relevant capabilities and concerns. We next look into the digital media applications and implications of cognitive architectures in general, many of which are unexplored. The chapter culminates in with the details of a specific architecture, Soar, and the considered implementation and capabilities of EST and narrative cognition within Soar.

4.1 Cognitive Architectures

Human cognition, though central to every human activity of interest including the artistic and expressive, is a black box: it is not yet possible for us to directly observe the workings of the human mind. As an approach to dealing with the mystery of cognition, a cognitive architecture represents a system-implemented theory of human cognition. While not definitively computer-implemented, often the term includes computer frameworks built to implement the theories. As an approach to cognitive psychology these programs provide opportunities in the first-degree to test psychological theories and, should the results be similar to human results on the same tests, gain support for the given model's cognitive feasibility. This then provides a wide range of second-degree utility as predictions on new tests can be extended to humans. Given a suitable cognitive architecture, we can use it to estimate the effectiveness programs or designs are likely to have for human recipients, or how humans may respond to an artifact.

In addition to serving as a psychological tool, cognitive architectures have also become an instrument in the field of artificial intelligence. Though researchers in the field of AI are not always concerned with how human cognition works, humans are generally considered the standard for intelligence. Cognitive architectures have become favored as AI systems that can be the brains behind robots and simulations. From this perspective the architecture represents a productive system, capable of generative behavior in its own right. And between these two poles–that of systems for approximating human cognition and systems to function as artificial intelligence–is the common ground of a system which, to some degree, will should be able to provide a more human-like collaborator in human-computer interaction scenarios, a use of interest from human-computer military teams to games and expressive AI experiences.

4.1.1 A Brief Overview of Cognitive Architectures

There are a variety of approaches to modelling cognition, each with a different central focus and separate themes. Cognitive architectures, by definition, tend to represent integrated approaches: that is, a system that strives to capture as much of the overall process of general cognition as possible–including memory, perception, knowledge, and learning. Such unified approaches are sometimes labelled unified general intelligence systems [31], but in this work we will refer to them as *Unified Theories* *of Cognition* (UTC), following Allen Newell's seminal work [95] and highlighting the fact that the systems being considered are both computer programs and also concrete theories modelling cognition. UTC are differentiated from expert systems, which aim to do a single thing very well but are neither general nor system-aware–that is, are less effectively poised to recognize system-level context or how different tools can share resources and contribute jointly to the design of a single system. In addition to the appeal of a system that provides flexibility and generality, UTC seem particularly well positioned to address the ubiquitousness and breadth of narrative, something that is hard to imagine any specialized, expert system addressing.

Cognitive architectures can be likened to structural architecture, which includes consideration of the walls and roof but is not usually concerned with furniture or wall-hangings. Likewise cognitive architectures are concerned with the general, unchanging qualities of a cognitive model: the memory systems, the ways memories can be represented within those systems, and the way those systems can be functionally utilized (including learning mechanisms), but not specific knowledge or pre-scripted applications.

Langley, Laird, and Rogers' recent consideration of the challenges and design considerations of cognitive architectures suggests that they can be defined by a set of capabilities and that they can be compared and differentiated by consideration of the properties that enable these capabilities [67]. The defining capabilities of an architecture include the recognition and categorization of data (especially environmental and contextual data), decision-making, perception, and execution of action. In addition, five other capabilities of cognitive architectures are particularly relevant to our approach to cognitive narrative: prediction and monitoring, problem solving and planning, belief maintenance, communication, and remembering. These latter five will be considered in turn. Of the five highlighted capabilities of cognitive architectures, most are related to this fundamental property of cognitive architectures: that applications of cognitive architectures exist over time. This leads to profound distinctions between cognitive architectures and programs or AI approaches of more static type, which exhibit a more-or-less timeless concept of memory or which are started afresh for each new (sub-)task.

4.1.1.1 Capability for Prediction

Prediction is required by systems that operate in sensitive environments, particularly those that include other agents. The importance of prediction for a cognitive agent is clear if we consider a car-driving AI, for instance, which needs to be able to assess the likely outcome of its own actions and those of any nearby drivers. Considered alongside prediction is monitoring, by which senses are related to predictions. Such child-like challenges as catching a rolled ball require facilities for prediction and monitoring.

The concept of narrative intelligence being discussed in this thesis is based fundamentally upon prediction, which is the process by which the events that compose narratives are generated from senses and experience. For cognitive architectures the call is to not only possess the ability to make predictions over classes of observations and their associated domains, but also to exhibit the ability to learn prediction models. As ability for prediction improves we can expect that the stories derived from the exceptions to more sophisticated prediction will also improve. This is could produce the kind of improvement in narrative maturity that is observed in children [13] [100, ch. 2].

4.1.1.2 Capability for Planning

UTC systems are expected to perform in novel situations and against problems that have not been seen before. For such tasks as these the system must be capable of generating a sequence of actions based upon its beliefs about the world and its predictions, which actions will achieve the system's goal. Not only is planning required for strategic endeavors like a chess game, without some form of planning capabilities the not-so intelligent agent would be unlikely to efficiently cross a room or achieve the most basic multi-step tasks.

Planning and expectation have been pointed out as among the cognitive functions for which humans often apply narrative [47, 50], and plans are one of the chief structures representing narrative in narrative generation systems [84]. An interest in planning provides common ground for a symbiotic relationship between cognitive architectures and narrative. Systems from both endeavors provide mechanisms that could be mutually beneficial for tasks of general and narrative intelligence. Inasmuch as different cognitive architectures approach the problem of planning differently each can suggest a different native conception of narrative structure in harmony with that arrangement of planning. For instance, the Soar architecture's planning-as-subgoaling has different implications for a narrative structure than the skill-hierarchy of the ICARUS system [66], both of which may invite interesting differences from the stories produced by the conventional backward-chaining approach to planning adopted by many narrative generation systems [69, 109]. With planning already established as a methodology for narrative generation, the inherent planning capabilities of cognitive architectures offer ready approaches for narrative generation within cognitive architectures while the converse insight into narrative's relationship to planning from the field of narrative generation promises useful resources as narrative intelligence is incorporated into UTC.

4.1.1.3 Capability for Belief Maintenance

Belief maintenance is paired with reasoning in the analysis of Langley *et al* [67]. In their context "belief" is a technical term referring to an agent's knowledge about a partially-observed world, and reasoning is responsible for generating beliefs from perception, knowledge, or other beliefs. In other words, a belief is knowledge that is subject to being incomplete or false but, nevertheless, is taken more-or-less factually for the time being. They give the example of a pilot who might conclude that an approaching plane is an enemy if it changes to an intercept course. For cognitive architectures reasoning and belief maintenance is centrally a concern of the representation of knowledge itself and, in particular, the representation of conceptual relationships–for example, Soar's directed graphs or the formal logic of PRODIGY [25].

Clearly this concern of cognitive architectures for belief maintenance is pertinent to narrative cognition, as narrative comprehension is itself centrally about maintaining an accurate set of beliefs as to the situation and prospects of a narrative (see section 2.2.1) and narrative coherence, one of the crucial axes of narrative quality, is closely related to the degree to which the readers' beliefs are managed by a narrative (i.e. reader beliefs about story world should be mostly satisfied with deliberate dramatic exception). In turn narratives, whether received by communication or from memory and experience, offer a crucial source of beliefs and a valuable resource for reasoning.

Belief maintenance is closely related to the concept of *story world* [136, 48, 82], the constructed reality that holds within a story and includes actions, internal history, characters, and rules of causality. Narratively-engaged humans are involved in a constant process of belief construction, maintenance, and revision in precisely the ways with which cognitive architectures are concerned.

4.1.1.4 Capability for Communication

As has been stated by cognitive scientist and design scholar Gerhard Fisher, "The power of the unaided individual mind is highly overrated" [35]. As tasks involving human-computer interaction, and even agent-agent computer interaction, become increasingly prevalent, the need for cognitive agents to communicate with humans and each other is pressingly obvious. Cognitive architectures, by very nature of their generality, need to be designed with communication in mind and consideration of the ability to translate and interpret signals to and from knowledge. Langley *et al* highlight the additional importance of episodic memory, above and beyond semantic memory, for communicative activities that refer to past events and cognitive activities. However, despite the need for extra-agent communication, the enormity of the task of bringing to bear language or other communicative facilities has resulted in only slow progress in the area of communication ability.

Upon this point narrative strikes with its primeval role as a means of communicating prior to even its role as entertainment [27, 115]. Communication has been highlighted as one of the key cognitive roles of narrative [50] (section 2.3). The gap between word-level understanding and actual discursive proficiency prompted some of the original pioneering forrays into computational narrative [120] and points to the key role narrative plays as a structure and intelligent capacity for rich contextual and affective communication. The efficiency of narrative for encoding rich social information has been remarked upon as a quality of central utility for narrative [81], and narratives have been considered “the most compact and informative structures” for representing high-volume event data [133]. These reasons provide strong support for the utility of narrative cognition in cognitive architectures, and inversely for the appropriateness of expressive applications of cognitive architectures for performing narrative roles in digital media programs.

4.1.1.5 Capability for Remembering

At first the notion of remembering as a significant capability of a cognitive architecture might seem obvious insomuch as computers are known for their memory capacities, since the dawn of the computer age. The difference for an architecture is that it is, to some extent, embodied as a complex cognitive system across a span of time within a rich situation. The capacity of remembering serves to highlight the fact that total encoding of all perception would be both undesirable and intractable for domains scaling upwards to real-world complexity, as well as insufficient for the needs of a cognitive system; in the design of a cognitive architecture decisions must be made as to what will be remembered, how it will be encoded, and when and how it will be recalled. For instance, Soar [61] is distinguished as one of the only architectures to support episodic memory that indexes instantiated data with time labels; EPIC [87] has distinct memory modules for visual, auditory, and touch data; and CLARION [124] uses neural networks to encode its perceptions. Each of these designs implicates different functions for retrieving memories and different assumptions about how memory works.

In addition to the obvious importance of memory design to decision-making, reflection and learning are dependent upon the memory systems. Reflection indicates the ability of an agent to target as the subject of its cognition its actual knowledge structures and the product of its previous cognition; for instance, for retrospection or re-analysis, when an agent might think about what it previously thought, or in our case, for re-evaluating or reforming a story in memory.

Learning is a final important capability of cognitive architectures, considered jointly with remembering and reflection, that is particularly relevant to the time-embedded nature of cognitive architectures: unlike many machine learning approaches that have an off-line learning phase prior to their actual execution, agents of cognitive architectures would need to perform learning while on-line during run-time. All of the architecture's systems that are relied upon by remembering are shared with any learning functions, which also take as their primary subject the actual knowledge structures being produced by the agent. Because narrative seems to constitute a primary knowledge structure in the human mind (section 2.3), narrative cognition is instrumental to learning. A narratively intelligent agent will also use narrative as one of the chief currencies of remembering and reflecting.

4.1.1.6 Episodic Memory and the Capabilities of Architectures

It has been established that a defining characteristic of cognitive architectures is that they exist in and through time. One of the implications of this fact is that episodic memory, which is centrally concerned with events in time, is particularly relevant to cognitive architectures. In addition, as has been discussed in chapter 3 episodic memory is inextricable from narrative cognition; applications for episodic memory are applications for narrative cognition, and implementation of narrative cognition promises benefits for the five highlighted capabilities.

Belief maintenance within AI systems has often been implemented without a strict concept of episodic memory (e.g. [90]). These systems dynamically track what is believed at the current time, which may be changed by new observations, but are usually unable to reflect upon any history of changes or to regard what was believed at a particular past point in time (though there are notable exceptions [30]). Episodic memory within a cognitive architecture can support reasoning that extends beyond the current belief state to trends in past belief states, and mechanisms for this sort of reasoning can be particularly relevant if applied to other agents to reason about their past and current likely belief states.

Prediction and planning benefit from the expectations provided by narratives, whether those narratives are experiential or mediated (section 2.3). This forms a virtuous cycle as the provided predictions are observed and the results are return to further strengthen or modify the next predictions. Plans are both recognized and created based upon previous plans, which can be encoded as narratives and, when brought to real-world and experiential context, are likely to take the form of forward-facing narratives. Indeed, mental "time travel" into the future is one of the functions of episodic memory within humans. Prediction is central to the notion of narrative cognition examined int his thesis, as the basic elements of narrative are seen as a product of failed predictions.

As has been previously mentioned the problem of communication is immense and, for this reason, has been daunting to developers and researchers of integrated architectures. However, it is an increasingly incumbent challenge that must be addressed, and it may be impossible to implement language proficiency on a discourse level without an episodic memory system to support it in obvious tasks like anaphora resolution and with speech acts and received narratives. Narrative is one of the most important forms of communication and is probably impossible to comprehend without some form of episodic memory [126, 12, 140]. For these reasons we may expect there to be little progress toward human-level communication in cognitive architectures until functions of episodic memory are implemented.

However, episodic memory has been implemented in very few cognitive architectures. This is likely in part because of the novel nature of episodic memory compared to the atemporal semantic memory, which is the standard notion of memory in most computer systems, and also in part due to traditional computer tasks not requiring episodic memory (for example, arithmetic is not typically a narrative process). Because of this, UTC applications of episodic memory have been little explored and there is much exploration to be done. Narrative cognition and narrative intelligence is a natural application for episodic memory.

4.1.2 Soar

The Soar cognitive architecture is one of the best-researched and most heavily applied cognitive architectures to date. Developed in the early 80s by Allen Newell, Paul Rosenbloom, and John Laird [58, 64, 65], the system stems in part from Newell's earlier work on a general problem solver [96]. The theme of generalization is in contrast to expert systems, one of the prevalent forms of AI that produce specially trained systems with highly specific knowledge and capabilities designed for a single task. Newell's work is distinctively human-facing and under his direction Soar developed

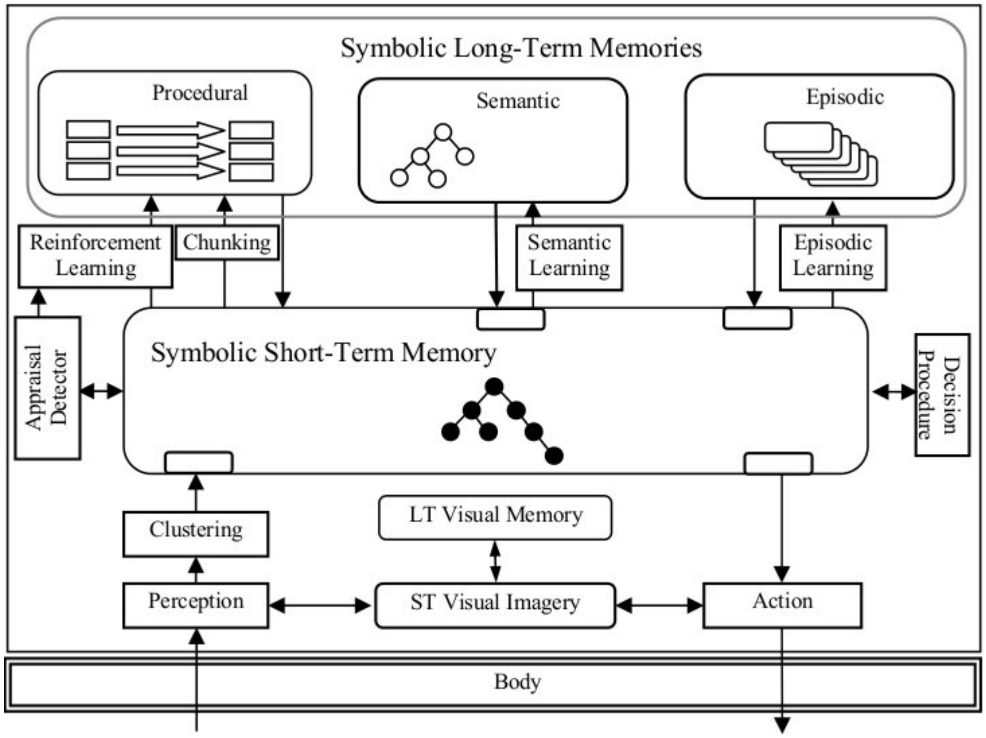

Figure 6: The Soar cognitive architecture [59]

simultaneously as a theory of human cognition, based on physical symbolic reasoning and a minimal set of architectural structures, and a computational realization of that theory. Newell's work ultimately found articulation in his production of the William James lectures and the resultant book *Unified Theories of Cognition* [95], wherein Newell calls for theories that attempt to address intelligence as a whole, and provides his own such theory which is incarnated in the Soar architecture. Newell designed the Soar architecture to reflect the concept of *problem spaces* [97, 98], in which intelligence is defined in terms of goal-directed problem-solving capability and problems are defined discretely, meaning that the approach to problem solving can be differentiated from the problem itself and, so long as different problem spaces can be defined, the same system can be used on a variety of the problem spaces. This general approach to intelligence provides certain advantages that are alluded to even in the title of Kelley and Long's article *Deep Blue Cannot Play Checkers* [53], which is particularly concerned with AI approaches that support real-world robots.

After the loss of Allen Newell (1927-1992) Soar's development continued under John Laird's supervision and drifted away from Newell's emphasis on human modelling. In his 2013 book Laird differentiates modern Soar from human modelling architectures like ACT-R [3] by calling Soar "human inspired" [61, p. 3]. This highlights several important points: first, in the field of AI cognition does not always imply human cognition. Second and resultant, cognitive architectures may not be concerned with human cognition so much as with producing intelligent behavior even if by means that are not "cognitively plausible" by human standards. While this point is important to understand the lay of the land in cognitive architecture research, it does not pose a problem for this work. While Laird's current emphasis in Soar development is not focused on human plausibility, changes to Soar in no way invalidate or remove functionality from Newell's work and do not jeopardize the concepts of narrative cognition that have been layed out in this thesis.

As has been mentioned Soar's emphasis on generality makes it a particularly strong candidate for implementation of narrative intelligence. Narrative's ubiquitous nature necessitates generality in any approach to capture it with any breadth, and so the similarity between a Soar problem space and a narrative story world is useful. Soar is also a symbolic system which means it is suited to capturing concepts of varying levels of abstraction, particularly at greater elevations of abstraction than connectionist systems may be able. Because stories themselves exhibit broadly abstracted features, such as the genres, schema, focalizers, and other generalizing features discussed in chapter 2 there is an acute advantage to the capacity of symbolic approaches to capture higher-level concepts. Finally, Soar is a particularly suitable candidate for implementation of narrative intelligence because it is one of the few cognitive architectures to support a form of episodic memory. While Soar's episodic memory does not precisely capture the concept of episodes or episodic memory as it is regarded in humans (see chapter 3), it does capture some dimension of time and provides a useful

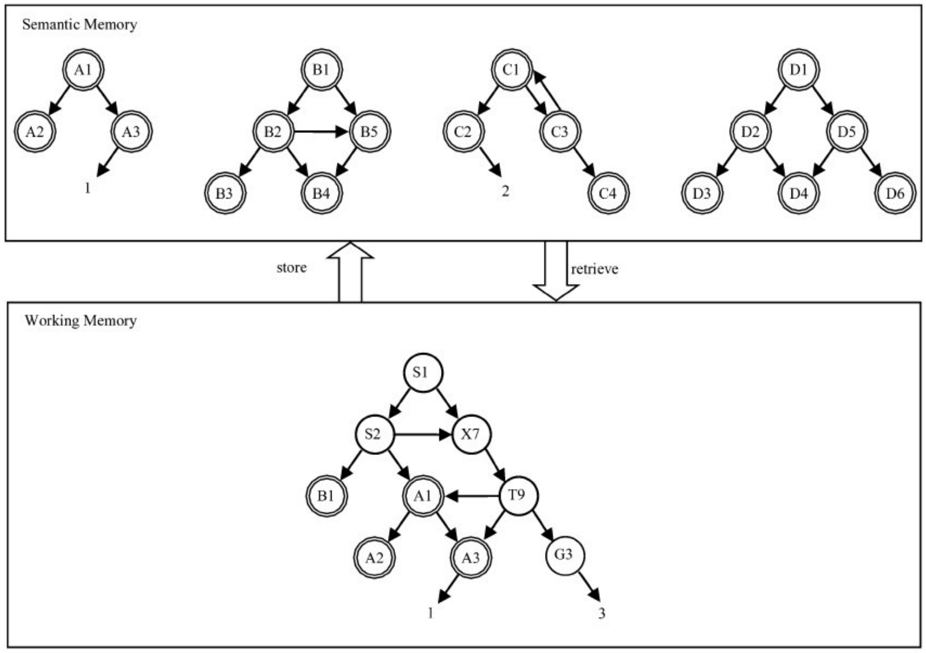

Figure 7: Soar's semantic and working memory systems [61]

starting point that will be discussed in greater detail below.

Soar has several key features of its operation which bear further discussion below. In turn we will consider: Soar's declarative knowledge representations, which can be represented as directed graphs and include memory. It is in these knowledge representations that any details of a story–for example, Hansel and Grettel's use of bread crumbs–would be encoded. Soar's procedural knowledge representations provide for rules and decision-making activities; such considerations as genre expectations and character decisions, as well as any instructions for story telling, could be here-encoded. Finally we will consider Soar's overall cycle of operation in which all the parts come together to produce the UTC.

4.1.2.1 Soar's Declarative Memory

Soar's declarative memory systems include working memory, episodic memory, and semantic memory, and have been optimized to run efficiently for rich-domain tasks like real-world robots for an hour or longer [63]. Each of these memory systems is represented as nodes along a directed graph where child concepts are located farther down the graph and can potentially be traced upwards to their ancestors, as pictured in figure 7. Working memory represents a Soar agent's awareness of the world around, including physical observations (e.g. for robotic systems), retrieved memories currently being brought to bear, and information generated by inferences and other reasoning processes (including concrete expectations and predictions). From a story-understanding perspective, the story world would be represented (at least partially) in working memory, including what characters are present, the understood knowledge-state of those characters, etc. Working memory is the most rapidly and regularly changing memory base.

In working memory all concepts–called Working Memory Elements (WMEs)–are decendents of a single root, the state. When substates are created the elements of that substate branch off common substate root. With Semantic memory, on the other hand, separate isolated structures exist. These represent independent facts that may need to persist and may not be specifically related to the situation at hand. While working memory exists only in the instant of the agent, semantic memory can be stored and populated between active lifetimes of a Soar agent and can be stored externally of the agent in a database.

Soar's episodic memory ("epmem," figure 8) is structured identically to working memory because, in fact, it it constitutes snapshots of working memory. Retrieving an episodic memory retrieves the full working memory of the agent at some point in time. Like semantic memory, episodic memory can be stored off-line so that an agent's memories can be retrieved over extended periods of time, essentially providing an extended lifetime for an agent.

Unlike human episodic memory, Soar's episodic memory is exhaustive and does not actually include a concept of what most would consider a requirement for being an episode: a sequence of events fixating on some notable happening. Each episode

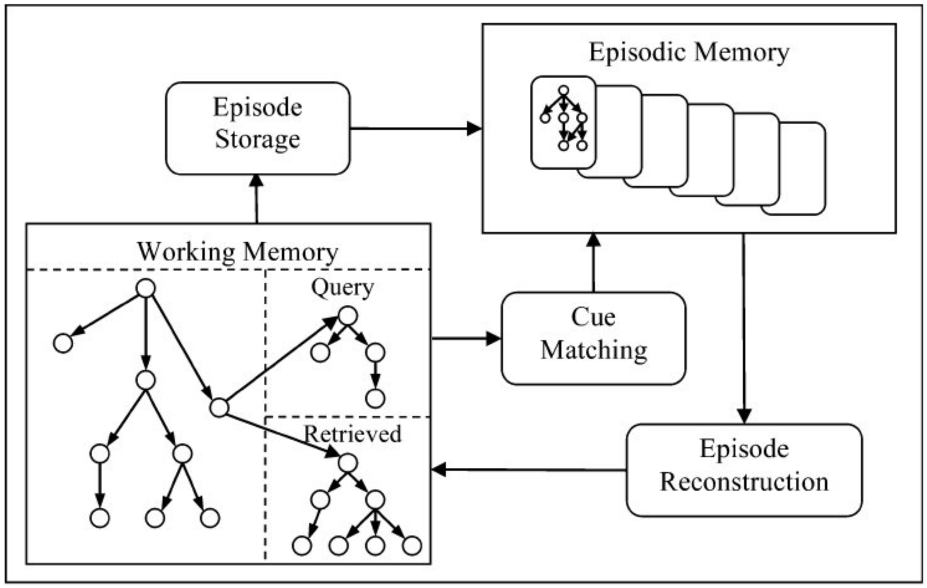

Figure 8: Soar's episodic memory system [61]

in epmem is a single state from Soar's experience with the only linking factors in epmem being the the time sequence by which epmem can be traversed forward and backward one state at a time. The only topography or delineation to epmem is the degree to which episodes match search queries, with each episodic snapshot being matched against a fragment of a graph knowledge structure so that searches like "memories with bread crumbs" can be retrieved. However, while this is a significant distinction from an actual narrative structure with causation and perhaps a dramatic arc, the principle of this thesis is to use the qualities of exhaustiveness and time-sequence available in Soar's episodic memory to construct narratives according to Event Segmentation Theory.

4.1.2.2 Soar's Production Memory and Rules

The declarative memory previously discussed represents memory concerned with details and specific observations, which is subject to frequent addition and modification. Soar's production memory (figure 9) can instead be thought of as memory for heuristics, logic rules, habits, and fast responses. For Hansel production memory might

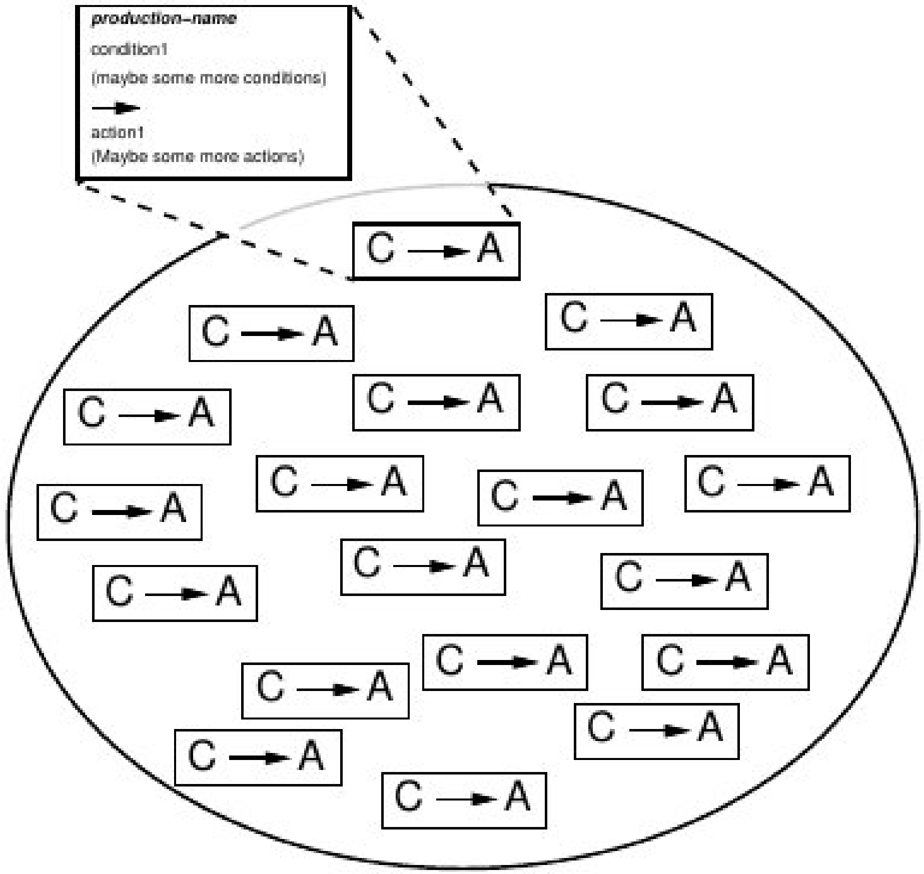

Figure 9: An abstract view of Soar's production memory, with unrelated productions [62, p. 16]

include the instruction that when something frightening (like that fast-approaching witch) is oncoming, run! The rules that are encoded into production memory can be thought of as if-then statements in which the conditions–referred to as "right hand side" or RHS–match against working memory and results–"left hand side" or LHS–alter or add to working memory, query either of the long-term declarative memory systems, or change preferences for operators.

Production memory is the primary working ground for Soar's learning systems. While acquisition of knew data is simply a matter of adding to one of the declarative memory systems, learning new skills is much more interesting. Soar makes this possible by what it refers to as "chunking" (different from psychology definitions of the term as an information grouping mechanism), by which Soar internalizes a result-producing process of cognition and maps the input directly to the output, optimizing the process by cutting out the middle-work. A trivial human example of Soar-style chunking would be to solve a simple math problem like 79 divided by 3. For us the solution might come about by first getting the nearest solution that we know, carrying digits or dividing for a decimal value, and finally producing our answer. Soar-style chunking would then simply memorize that $79/3 = 26.333$ and future encounters with the problem would then, essentially, be solved by checking memory, rather than performing any of the calculations that were originally needed. In a task of story telling, chunking could be responsible, for example, for learning when to change scenes/focalizers.

If, drawing upon the perspective of Propp's narrative structure and generation discussed in sections 2.2.2 and for narrative generation in section 2.4.2, we decompose stories into a triad of fabula, sjuzhet, and text, we could consider the fabula as being stored in long-term (declarative) memory and the rules in production memory as resulting in the system's storytelling ability as they work up on the fabula to compose an plan for telling the story (sjuzhet) and then output the actual telling (text). For our task of narrative cognition procedural memory will be most important for encoding the means by which narrative cognition actually occurs, accounting, for example, for the five functions of narrative instrumentality enumerated by Herman ([50], section 2.3). Most importantly to this thesis, even prior to that implementation of narrative intelligence, procedural memory will encode the means by which EST is implemented to construct narratives from episodic experiences (the focus of section 4.2).

4.2 A Theory of NI-Soar

Soar's episodic memory modules (epmem) depicted in the top right corner of figure 6 were added relatively recently and are our central focus. Soar's epmem works by storing snapshots of the working memory state (i.e. the Soar agent's awareness) at each time step, attaching to each snapshot a unique index representing the time of the memory. Once Soar has recalled an episodic memory it is possible to increment forward or backward through the neighboring episodes. Retrieval of episodic memory occurs as queries are issued searching for matching or partially matching features in the graph-structure knowledge representation. Results are given a match score based on how much of the query-graph matches the graphs in an episode, and the best match is returned.

The aim of this project is to outline the addition of fundamental narrative intelligence within the Soar theory of cognition (hence NI-Soar); we propose to start with narrative intelligence on the most basic of levels, not aspiring beyond child-level narrative intelligence at this point. With this starting point groundwork is laid for future work refining the model.

The implementation proposed proceeds as follows: Soar provides sensory input which is represented in working memory and stored over time as episodes in epmem. These provide the information stream required by EST to make the predictions that result in discrete events. These events are the building blocks of narratives according to the simple definition of narrative as consisting of a sequence of causally related events, which also allows for the consideration of narrative as consisting of as little as a single event (as may be seen with a child's first narratives).

4.2.1 Predictions

At the heart of EST is the making of predictions, which may receive input from a variety of sources including scripts and schema, behavioral character models, genre expectations, and other inputs from semantic memory. As has been previously mentioned the resources available for these processes develops with the experience of the agent. As this exploration considers naive agents with a minimum of prior knowledge it is desirable to have universal heuristics that can form the basis for prediction across domains. Making the simplification of a world consisting of agentive and non-agentive components we consider two heuristics purely as a starting point. Both of these stand to be superceded as knowledge is gained by the agent.

The heuristic of inertia pertains to non-agentive components of the world, such as spatial configurations. The agent may predict that its environment will continue to exhibit the same features that it now exhibits.

The heuristic of auto-simulation applies to agentive components of the world and takes one of the simplest approaches to a theory of mind by assuming that a perceived agent will act in the same way as the perceiver.

These heuristics are admittedly simplistic but provide a ground case to create predictions in any situation, the violation of which delineates the events necessary to form narratives. The result is a stream of events that is, in the worst case of a rapidly and inscrutably changing environment, identical to epmem and will, with any stability to the environment or shared rationality of the agents, be an abstraction over the episodes.

4.2.2 Linking Events Into Narratives

The definition of narrative here adopted has sometimes been interpreted as allowing for single-event narratives, as when a toddler recalls repeatedly that today "I fell down." Such interpretation draws no distinction between *event* and *narrative*, a point of ambiguity further promulgated by Zacks' explanations of EST.

The distinction we propose is not one of structure but of function.

EST provides events as a natural kind by which we perceive the world, just as we discern discrete objects. According to EST this perception can occur reflexively. Narrative, on the contrary, is deliberate and negotiated.

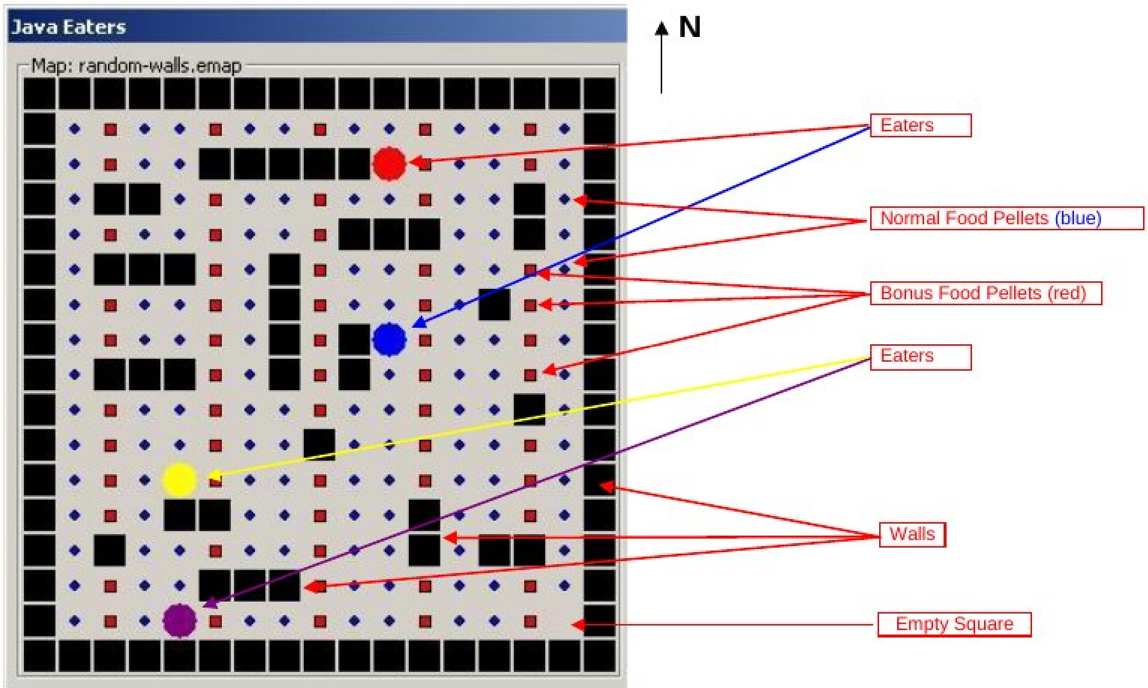

Figure 10: An explanatory screenshot of Soar's Eaters game [60]

4.2.3 Considering a Domain: Eaters

While Soar is fully capable of recording the richness of real-world perception (e.g. in its robotic applications), generating the events with EST which are requisite for narrative generation requires that the system be capable of making useful predictions, which in turn requires rules capturing the complexity of the domain. Games make useful simplified domains that can produce readily observable results. Soar ships with several game domains that can make testing-grounds for introductory exploration of this approach; we take as an example the Eaters domain [92].

The Eaters game (figure 10, [60]) is a two-dimensional Pacman-like game in which one or more colorful "eaters" navigate within a randomly generated maze with the goal of achieving the high score by consuming food pellets of lesser or greater point-values. The eaters are capable of only two types of action: moving one space at a time in any of the four cardinal directions, which type of movement has no cost, or jumping up to two squares away, which costs the equivalent of a lesser food pellet. By jumping, an Eater can pass over an obstacle but never consumes food over which it has jumped. When eaters collide, they are each randomly transported elsewhere in the world and their scores are averaged with each other. Each Eater agent has a limited range of vision and discovers the world as it moves. This feature of partial-observability is desirable for mechanisms that rely upon prediction, as does an EST-based approach to narrative intelligence.

Even within so simple a domain as Eaters prediction is still possible and interesting. Because of the partially-observed nature of the domain a natural opportunity for prediction is in world-state itself. For example, will the given wall continue indefinitely? For how long will the current trail of food proceed? Predictions answering these sorts of questions about world-state are possible even in one-agent scenarios. If scenarios admit multiple participants, more complex prediction becomes possible based on changes to world state (in Eaters, the consumption of food) and direct observations of other agents. Changes in the world state make an ideal opportunity for event segmentation as such changes are likely to be unexpected. Behavioral prediction becomes possible if agents in a multi-agent scenario are permitted some degree of a theory of mind, with a naïve implementation being to assume that other agents will perform as would the subject agent. More sophisticated behavioral models might enable an agent to comprehend the possibility of alternative possible goals in opposing agents, with event boundaries providing an ideal opportunity for evaluation and modification of the model it attributes to other agents.

4.3 Discussion and Conclusions

Successful application of EST will produce events from epmem; an event will consist of some number of episodes. A narrative, then, consists of one or more events. As Ochs' recounts, children often begin their narrative practice by creating one-event stories [100], with the narratives growing in complexity as the children mature. Thus, while the approach outlined will produce child-like narratives, there is wide room for future work that considers ways of composing compound narratives from atomic narratives. Such considerations from researchers like Propp form the basis of modern narratology and continue to be explored [105, 42, 34]. The proposal of this work is that single-event narratives of the sort produced by EST with Soar are atomic and may serve as building-blocks for any other narrative structures.

Eventually narrative intelligence will be an instrument for general intelligence, at which time we could expect that agents with greater narrative intelligence would have a competitive advantage in games like Eaters. As an introductory exploration, the chief product of the approach proposed are the narratives themselves, preliminary to more advanced functions of intelligence. However child-like (even toddler-like) these minimal narratives may be at the start, the function that can provide them will meet needs of both quality and quantity.

A system that is able to continually produce narratives from its experiences has the potential to offer the sort of statistical data valuable for categorization and norm detection, both considered some of the fundamental purposes of cognitive narrative in humans [47]. It also offers a promising starting-place for automated generation of scripts within a domain, which could be a useful complement to crowd-sourced script generation that can be costly and unpredictable [73]. Together, these capabilities may serve in support of advanced cognition like goal-based reasoning [114], whereby consideration of narrative schema could provide resources for adaptation or change of goals in dynamic scenarios.

Regardless of the episodic memory implementation, a system that produces experiential narratives will also capture qualities of coherence that are desirable in a narrative system. Insofar as narrative is concerned with having a “continuant subject,” experiential narratives minimally satisfy that by providing the experiencer as subject. This fact is not insignificant for applications in Human-Computer Interactions, Expressive AI, or Affective Computing, where "self" for continuity of subject may provide resources for desirable development of personality and style within an agent [54].

A concluding line of work worth mentioning would be observer-systems which would consider primarily other agents as the subject of their predictions and narratives. Such systems would enhance the quality of the narratives generated by developing narratives based on human or expert-system performance and would be important steps toward tasks such as automated sports commentary [2], summarization [107, 70], and theory of mind [43]. One of the severe challenges facing the development of effective observer systems is having an approach to narrative intelligence that can be generalized across domains. The development of general story-generation algorithms suitable for general cognitive architectures is one strategy for approaching such useful systems; hopefully the approach discussed here is a step in that direction.

CHAPTER V

CONCLUSION

5.1 Summary

This thesis has provided a broad literature review and a theory for narrative cognition. The literature review includes narrative approaches from drama, communication and social theories, literary approaches, and computational approaches. In particular emphasis is placed on the notions of cognitive narrative, both as they have been proceeded as developments from traditional narratology and as they are related to mechanisms in cognitive psychology. The result is a focusing upon narrative not as a special case or by distinct artifacts, but rather as a human universal irrespective of society, media, or language.

The addition of computational narrative approaches to the theoretical discussion serves several purposes. First, this is regarded as a development as natural and no less significant than historical narrative innovations like the novel, which itself served to alter the form, consumption, and understood nature of stories. Computational narrative offers new ways of creating traditional-form narratives, of experiencing new forms of narratives, and of processing the increasing wealth of narratives that continually surrounds us.

The approach to cognitive narrative outlined in this thesis might also be regarded as computational, insomuch as a computationally realized cognitive architecture is considered and approaches from artificial intelligence (including some of those used in the computational narrative systems considered in 2.4) are relevant and applicable. It is distinct, however, in that it is specifically centered on the notion of cognitive narrative, taking into account human cognitive systems and aiming for a concept of narrative that appeals to the ideas and evidence of natural narrative rather than former theoretical forms devised from the critical arts; it also is not motivated firstly by functional or generative concerns, which are considered to be a side-effect or sub-process of narrative cognition rather than the singular reason for it.

The theory for narrative cognition advanced in chapter 4 starts with perception, and is suited to life-long, constant application and improvement in an agent. It suggests that the perceptual process of event segmentation is a fundamental source of narrative cognition, and that the events produced by the processes of EST are the original cognitive building-blocks of narratives. Using the idea of graded narrativity, bare events and early event segments will generally be poor narratives (i.e. exhibiting relatively little narrativity, including little tellability or interest to an audience); this is consistent with the development of narrative abilities observed in children, whose early narratives are of limited coherence and relatively boring by more narratively-experienced standards. While these early, individuated segments may perhaps be considered as impoverished narratives, in principal narratives bear important distinctions from their constituent events as produced by EST.

A first distinction of narratives from EST events is that events are considered automatic and fundamental; event segmentation occurs as a process of perception, automatically and continuously. While declarative knowledge structures have bearing on the processes of event segmentation, particularly through event schemata and event models, the bulk of event segmentation occurs without conscious supervision. Applying, again, the notion of narrativity, it can be suggested that these event segments can become increasingly narrativized as they make more frequent use of increasingly large narrative structures from memory; as they do so they will tend toward composed narratives and away from exemplars of raw events. Archetypal cognitive narratives, on the other hand, bear the distinction of being deliberate. This is suggested by the prevalence of analytic decomposition throughout the dramatic, literary, and other fields, and also by the long-standing consideration of authoring processes, which is by nature a process of mental effort. The literature on natural narratives also reveals narrative-making to be a durational, sequential process, often interactive and negotiated. Each of these bodies of research supports narrative-making as being fundamentally deliberate, unlike event segmentation.

A second key distinction can be teased out by noting the different uses of the declarative memory systems by EST; EST recognizes the crucial contributions of semantic memory to the segmentation process, for example in the use of narrative structures to parse information, but episodic memory is usually more the recipient of the products of EST than a contributor to them. Nonetheless we regard episodic memory as fundamental to narrative cognition, as the storage for narratives themselves (though research remains to determine how much, and what parts, of structured narratives are actually stored anywhere) as well as the the primary source of events (we may even say "episodes") that will be manipulated by narrative cognition for activities that include narrative generation. This differing use of the memory systems highlights the second property of cognitive narrative as distinct from events: narrative is often the product of reflection spanning distances of time, rather than nearly instantaneous as is perceptual event segmentation. This feature of cognitive narrative exposes one of the major mechanisms of narrative cognition as opposed to event segmentation: the use of narrative functions upon memory rather than upon perception. While perception itself, and hence events, are hierarchical, this quality is redoubled upon narrative because of the capability for deliberate composition and reanalysis over [narrative] memories, even cyclically and recursively.

Our theory of narrative cognition is related to and reliant upon Event Segmentation, but bears the distinct differences we've reviewed: that narratives are deliberate, and that narrative cognition need not (indeed, often is not) instantaneous but reflective, recursive, and analytic.

5.2 *Key Concepts*

Three general definitions follow from this thesis theory for narrative cognition, which may have impact upon larger bodies of narratology.

5.2.1 Cognitive Narrative

Cognitive narrative is narrative as a mental object, stored primarily in the episodic memory system. It consists of events segmented into episodes. It is deliberately created and exhibits hierarchicality, temporality and sequence, and malleability. It is subject to and structured to be a resource for application of the functions of **narrative cognition**. It is chiefly evaluated according to metrics of **narrative quality**.

The concept of cognitive narrative that arises from the theory of this thesis is closely related to natural narrative, which is the personal narrative of everyday experience. We consider cognitive narrative to be the mental form of narrative that gives rise to expressions of natural narrative and which is being modified and refined by the discursive practices of personal narrative; bearing linguistic analogy, cognitive narrative is to personal narrative (and surely some formal narrative) what deep structure is to surface structure in linguistic syntactics–meaning, a hidden, inchoate structure that is responsive to operations (re: narrative cognition) before being realized in a recognizable surface form.

The concept of deep structures of narrative is as old as narratology and is most clearly seen in Propp's concept of *fabula*. However, the fabula was conceived by Propp as an analytic tool, a means of describing narrative properties and organizing formal study without making any claims as to cognitive plausibility or consideration of being subject to systemic processes. The fabula represents the time-line and event-stream of the story, subject to reorganization and filtering as the *sjuzhet* and *text* arise from it. Cognitive narrative, on the other hand, is considered as part of the cognitive system interacting with the functions and systems of the human cognitive architecture, which brings with it a host of implications with bearing on future work. It is recognized as, itself, derived from experience or received narratives, rather than as an archetypal progenitor created *ex nihilo*.

The theory proposed for the development of cognitive narrative within a long-lived agent opens the door for further work exploring the structure and properties of cognitive narrative. That said, some key properties are inherited from the roots in perception and suggested by existing cognitivist approaches to narrative. One of the most prominent is that of hierarchicality. Perception inherently incorporates multiple levels of abstraction; this is likewise a trait of narrative, which magnifies this trait because of its longitudinal, memory-based nature which allows hierarchicality and recursion to be seen over greater spans than the short-term range of sensory perception. Where event hierarchicality and parse sequences of hand and object motion into "catching" or "throwing," cognitive narrative lends itself to broad categorization as "tragedy" or "attempted murder," or of being in service to a moral/theme, or on to broader and broader structures up to national, theological, historical or cultural meta-narratives.

5.2.2 Narrative Cognition

Narrative cognition is the process by which cognitive narratives are manipulated, generated, and applied. From a functional perspective, any function which takes as input a [cognitive] narrative or produces as output a [cognitive] narrative is a form of narrative cognition (the "cognitive" nature of a narrative is implied by any narrative which interacts with or passes through a mind). In the broadest sense we may define narrative cognition as an extension of Newell's definition of intelligence:

> **Intelligence:** "The ability to bring to bear all the knowledge that one has in the service of one's goals." [95, p. 90]
>
> **Narrative Cognition:** The ability to apply narrative in the service of

intelligence.

Note that the definition of narrative cognition provided above has three implications when seen through Newell's definition of intelligence: narratives may be of use in "bringing to bear," particularly organizing and arranging knowledge; they may be of use in contributing to "the knowledge one has," particularly when used to understand the world or the actions of individuals and to update beliefs; and they may focused on "one's goals" in a number of ways including for goal reasoning (selecting/changing of goals) or for the application of narrative functions.

The means by which cognitive narratives undergo application is surely broad and remains to be explored across the range of domains, and this thesis has been chiefly concerned with only the function of narrative generation from experience; nonetheless, we can enumerate a number of functions suggested by the literature, many provided by Herman [50]:

- Narrative generation from experience.
- Narrative comprehension.
- Storytelling, which will require a host of functions of its own.
- Analogy, a process by no means singular to narrative, but certainly of first-order concern to it.
- Imputing causality.
- Typifying phenomena (which probably shares process with narrative analogy).
- Sequencing (future) actions.
- Distributing intelligence.

5.2.3 Narrative Quality

Crucial to our discussion of cognitive narrative is a means of evaluation that can also guide function of narrative cognition. To this end we enlist Walter Fisher's concept of narrative rationality, which is echoed in concepts of narrative evaluation in narrative generation, and which we believe applies to cognition: that cognitive narrative is principally evaluated with respect to *coherence* and *fidelity*; in other words, with intra-story and inter-story parsimony of the narrative, where inter-story is understood to pertain to life-stories and experiential narratives, in particular (e.g. for a religious individual, is the story compatible with the qualities they attribute to an over-ruling god and the rules they ascribe to His world?).

We assert that coherence and fidelity are the significant dimensions for measurement of narrative quality, but we do not at this time encroach on future researcher's explorations as to the best means of measuring these dimensions or evaluating the trade-off between the two, which has been a question in flux throughout the history of storytelling. To make a broad simplification, the more ancient the narrative the more fidelity was valued over coherence, such that animals magic could make ends meet and characters or gods could act irrationally so long as an appeal to a supposed real-world principle or observation was produced, so that thunder was god-made and tragedies were cautionary. Today, on the other hand, the ability to escape ever-more completely into a fantasy narrative with a consistent world and believable characters is highly valued.

5.3 Scope, Limitations, and Future Work

This thesis explores an initial theory of narrative cognition as phenomenological, event-based, and originally perceptually derived. However, such an undertaking is necessarily preliminary. While it is hoped that this theory provides a firm foundation for future work, such future work is critically needed.

Of first concern is scope. This theory proposes perceptual events as the atomic unit of narrative, or as the seed from which narratives arise. This establishes the smallest possible scope for a narrative while admitting the role for coarser-granularity inputs that have yet to be clearly defined. Such inputs may effect narrative cognition in two places: at the event-perception level narrative structures that include such things as culture, emotions, and identity can provide event schemata that effect the event models used to form events. At the reflective, memory-oriented level these inputs will play a similar role over a wider and larger range of narratives. Future research on the role of culture, for example, upon narratives and cognition can find theoretical utility by exploration through this theory.

Related to the issue of differing scopes of inputs, work remains for methods of working with different scopes of narratives themselves; as the size of episodic memory grows, how shall narratives be constructed from this memory base? What shall be the boundaries of generated narratives, and when shall small/short narratives be preferred to large/long narratives? This issue is unfamiliar to work on semantic memory, which is isolated by nature, but narrative may be infinitely composable, therefore requiring practical boundaries upon narrative recursion and composition. In addition to insights from computational theory, there are likely insights to be had from cognitive science upon the stopping-points for reflective narrative generation.

The theory in chapter 4 includes a pair of general heuristics designed to make predictions possible at all times. The rules that allow prediction are a point of further study that is of importance to all of event segmentation, with potential for special rules that work in narrative cognition. Both general rules and domain-specific rules need to be refined. Of particular importance is the development of theories to account for the learning and improving of predictive ability; this is particularly relevant to narrative cognition as typification and expectation are among the functions of narrative cognition mentioned above.

A final point of primary importance for future work is the development of the narrative cognition functions laid out in section 5.2.2. For applications in information analysis or learning systems, most important may be functions for narrative comprehension by which a cognitive system is able to meaningfully process inputs other than first-hand experiential information. For applications in games, entertainment, and expressive AI, storytelling functions by which the narrative base is variably transformed and communicated will be of top priority. Finally, while all of these will have import and shed insight on human cognition, work on functions for analogy (a fundamental function of general intelligence) and distributing intelligence will be particularly relevant to the ways in which narrative cognition can guide education initiatives.

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