1 Narrative as/and Complex System/s

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What does it mean to say “narrative is complex” or “narrative is a complex system”? Complex compared to what: ordering a beer, following a recipe, proving a theorem? Are all narratives complex or only some of them—the ones considered “literary” or, to extend the idea to all media, the ones considered artistic? Is the scientific notion of complexity useful to narrative theory, or should narrative theory develop its own notion of complexity? Such are the questions that I propose to address in this chapter.

In systems theory complexity is associated with concepts such as emergence, nonlinearity, decentralized control, feedback loops, recursion, self-organization, simulation, and distributed intelligence and with formulas such as “the whole is more than the sum of its parts” or “small events can have vast consequences” (the famous butterfly effect). The so-called science of complexity is a loosely defined field that extends into many disciplines and covers a wide variety of phenomena: the organization of ant colonies and beehives; the mode of operation of the brain; the fluctuations of the stock market; the evolution of species; the development of the weather; the organization of the World Wide Web; and the functioning of the immune system, to name only a few. What these systems have in common, according to scientist Melanie Mitchell, is (a) collective behavior: they are made of a number of individual elements that follow relatively simple rules, without the guidance of a leader; (b) signal and information processing: all these systems produce signals, exchanged both internally (i.e., between their components) and externally (between the system and its external environment); and (c) adaptation: these systems change their behavior according to the circumstances, to improve their chance of survival (2011, 12–13). Though there is no unanimously accepted definition of complexity, nor a fixed set of transdisciplinary criteria for measuring and comparing complexity across systems, these conditions lead Mitchell to the following definition: a complex system is "a system in which large networks of components with no central control give rise to complex collective behavior, sophisticated information processing and adaptation via learning or evolution" (13). (Note, however, the redundancy, which points to the difficulty of defining complexity: a complex system is one that "give[s] rise to complex collective behavior" and "sophisticated [or complex] information processing.")

Other scientists dispute the necessity of adaptation: the late John Holland, a leading authority in the field, argued that there are two types of complexity: complex physical systems, or CPS, and complex adaptive systems, or CAS (2014, 6–9). An example of CPS is a cellular automaton, such as John Conway's famous *Game of Life*: in a cellular automation, a set of rules is applied over and over again to dots arranged on a grid, causing the global state of the system to change and resulting in unpredictable visual patterns, but the rules remain the same, and the system evolves on its own without input from the designer ("Conway's Game of Life" 2018). In a CAS, by contrast, "the elements, usually called agents, learn to adapt in response to interaction with other agents" (Holland 2014, 8). Moreover, "as the agents adapt to each other, new agents with new strategies usually emerge" (9).

Whether or not the individual components of a system are capable of adaptation, the trademark of complex systems is the lack of a central controlling entity, comparable to the CPU of a computer, that pursues deliberate goals. Out of the simple rules followed by the components of complex systems arise (or more precisely, emerge) patterns and behaviors that could not be predicted by simply looking at the rules or by solving an equation. Therein resides the difference between a simple, linear system and a complex system. With a simple system there is a formula (an equation) that makes it possible to calculate the state of the system at a given time without calculating all the previous states. For instance, if a car moves at a steady speed of a hundred kilometers per hour, we know how far it has gone at a certain time by giving a value to t in the equation $x = 100t$, where t represents the number of hours the car has been traveling and x the distance, without having to calculate how far it has gone at time t-1, t-2, and so on. But with a complex system, such as a cellular automaton, there is no equation that predicts future states. To know what the global state of the system will be like at time *t*, it is necessary to compute its state at all preceding times, by recursively applying its rules to their own output (or new rules if there is adaptation). In other words, the state of a complex system at a future time *t* cannot be directly calculated, but it can be obtained through a simulation. There is consequently a close relation between emergence and simulation: we run a simulation to discover emergent properties; conversely, a property is emergent, when it can be discovered only though a simulation.

An often cited example of a complex, emergent system is the ant colony (Johnson 2001). An ant colony consists of large numbers of individuals who follow very simple rules: they forage for food, they fight intruders, they leave chemical signals when they find food, and they respond to the signals left by other ants by joining in the trail. No ant has a global plan for the building and maintenance of the colony—in fact no ant may even be aware of its existence. Yet, as Mitchell explains, "the ants in a colony, each performing its own relatively simple actions, work together to build astoundingly complex structures that are clearly of great importance to the survival of the colony as a whole" (2011, 4). A stunning example of this cooperation is the building of bridges, where ants use their own bodies to allow the passage of the colony over a gap. When the units of one level combine to form units of a higher level, the whole becomes more than the sum of its parts, and the system is hierarchical. This property is regarded by scientists (i.e., Holland 2014, 4) as the trademark of nonlinearity.

Given this all-too-brief survey of the key concepts of complexity theory, how can one address the issue of narrative complexity? The notion of complexity was not invented by scientists, and it is quite possible to develop an approach that owes nothing to them. Moreover, the idea of narrative complexity can be conceived in two ways: as a property of narrative in general or as a property of certain narratives, so the set of all stories can be ranked on a continuum running from simple (minimal) stories to maximally complex ones. By cross-classifying dichotomies we can divide the study of narrative complexity into four categories:

1. An approach, not inspired by science, to the complexity inherent to all narratives

2. An approach, not inspired by science, to the complexity of a subset of all narratives
3. An approach, inspired by science, to the complexity inherent to all narratives
4. An approach, inspired by science, to the complexity of a subset of all narratives

Here I concentrate on points 3 and 4, leaving their distinction to the conclusion. But the criteria for considering an approach as inspired by science are rather loose. Complexity fascinates, and some of the keywords of complexity science, such as emergence, nonlinearity, and feedback loops have infiltrated literary-critical discourse (for instance, see Hayles 2005), but it is very difficult to draw a line between those uses that are too highly metaphorical to deserve serious consideration and those that involve a reasonably close, interesting analogy between two domains that remain far apart in their objects and methods. If we compare the concepts of complexity theory to those of physics, such as force, mass, energy, gravity, entropy, superposition, and so on, we find that they are often not original to the field and that their meaning is extremely vague: there are at least thirty-one different scientific definitions of complexity (Horgan 1995, 107). This vagueness explains, in part, their popularity with literary critics, but it also questions their scientific status—a questioning that actually extends to the whole field of complexity theory.[1] My standard of "scientificity" will therefore rest on the use of two concepts that theorists regard as constitutive of complex systems: (1) decentralized control and (2) emergence. It may seem artificial to study them separately, since decentralized control is a prerequisite for emergence: "Emergence refers to the spontaneous creation of order and functionality from the bottom up" (Page 2009, 20). Yet although emergence presupposes decentralized control, these two concepts have distinct narrative applications.

Decentralized Control

At first sight narrative and complex systems are polar opposites: complexity rejects the idea of a system controlled from the top down by a central authority, but narratives are the work of an author or authorial collective. Complex systems constantly evolve, often in unpredictable ways, but narrative, once inscribed on the page or in celluloid, no longer changes. Yet if we move from the level of author-text relations to the level of the plot, the comparison of narrative and complex systems become much more productive.

For a narrative application of complexity theory, I propose to go back to Mitchell's (2011) definition of complex systems quoted on the first page of this chapter. The elements mentioned in condition (a) can be associated with characters and the rules that control their behavior with the principles that motivate character actions: goals, plans, desires, fears, and values. The exchange of signals of condition (b) correspond to the circulation of information between characters (mostly through dialogue) and between characters and the world at large, and the adaptive behavior of condition (c) is represented by the characters' ability to react to changes in the global state of the storyworld. From the three conditions we can thus derive a reasonably accurate model of plot. Prototypical narratives are about dynamic networks of human (or humanlike) relations, and these networks can be conceived, at least to some extent, as complex systems. The analogy requires, however, some adaptations: the number of elements is far smaller in narrative than in most complex systems; the rules that motivate the behavior of characters are not nearly as simple as those that govern the behavior of ants or of dots in a cellular automaton; the elements of the system follow their own personal rules rather than all behaving according to the same principles; and adaptation means that the rules can change as the characters evaluate new situations. Humans, unlike ants, are able to alter their behavior, which is why human societies are much more susceptible to change (and narratively much more interesting) than ant colonies.

While authors control characters and plots from the top down, using them to pursue certain artistic goals or to demonstrate certain moral or ideological theses, within the fictional world there is no central controlling instance.[2] Characters think of themselves as freely acting human beings, and they know nothing of authorial designs. Plots may be dominated by one character, namely the hero, but this does not mean that heroes are central controlling units, because there are lots of events that they cannot control, such as the machinations of the villain. Good plots emerge out of the conflict between different personal goals: if the goals of the characters were fully compatible, there would be no story worth telling. Narrative is therefore a top-down, centrally controlled system on the level of authorial design, but it must give the impression of an emergent, bottom-up system on the level of plot. A proper balance between these two types of control is essential to the aesthetic success of narrative. Readers must be aware that characters are authorial creations in the service of a global design, but they must also regard them as autonomous agents. When the actions of characters are too obviously dictated by the interest of the plot, this is perceived as a "cheap plot trick" (Ryan 2009), this is to say, as an authorial failure.

Human interactions, the proper stuff of narrative, may be too complex to be generated by cellular automata (at least in their current state of development), but by insisting on a systemic interconnection of elements, complexity theory can inspire a network-based approach to narrative (as developed in Poulaki 2014).[3] One type of relation that lends itself particularly well to network analysis is who among the characters interacts with whom in direct acts of communication. The importance of a character for a plot is at least in part a function of what is called its "degree" in network theory, that is, the number of connections leading in or out of the node that represents this character. In general, the higher the degree, the more important the character. Diagramming interactions between characters makes it also possible to distinguish several types of plot. The network for an episodic or epic narrative (figure 1), such as the "journey of the hero" pattern or a bildungsroman, would show a heavily connected character who encounters many different characters, but connections between groups of characters will be very few or nonexistent: each episode tends to have its own cast.[4] The network of the so-called it-narrative, or circulation narrative (a genre popular in the eighteenth century that retraces the travel of an object, such as a bank note, through multiple owners), would show several reasonably dense networks (corresponding to the various stories), connected to one another through the possession of a common object or through a single connection, corresponding to a character who serves as mediator (figure 2; note that to account for change of possession of the object within a story it would take a different kind of diagram). This structural type also describes narratives with multiple, distinct stories taking place in the same storyworld, such as *Cloud Atlas*, by David Mitchell. The networks of dramatic narratives (figure 3, for Jean Racine's *Phèdre*) are more densely connected: charac-

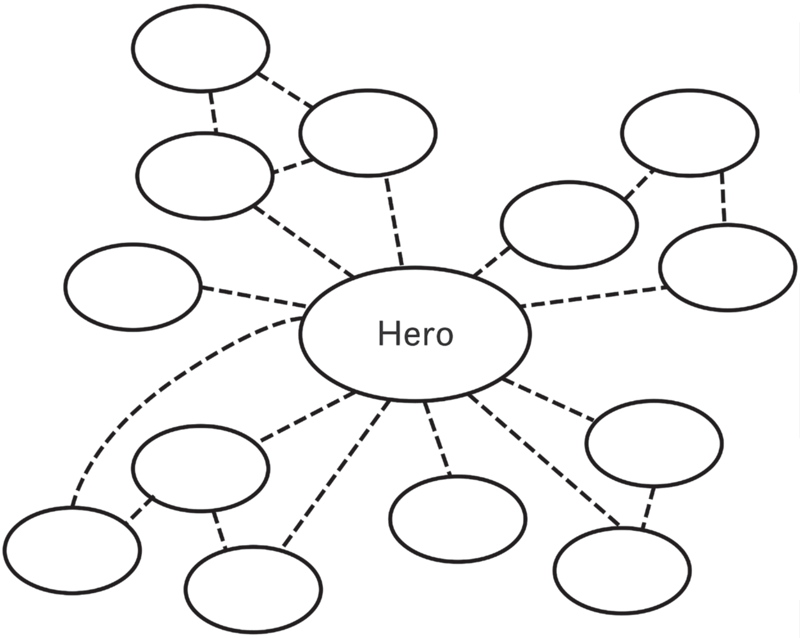

Fig. 1. Network of an episodic or epic narrative. Created by the author.

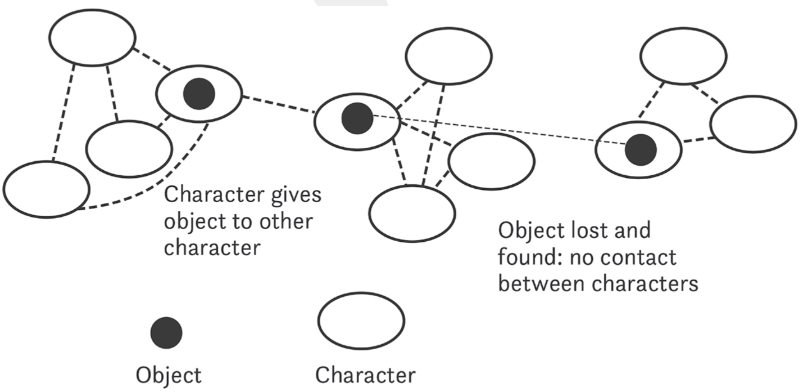

Fig. 2. Network of an it-narrative. Created by the author.

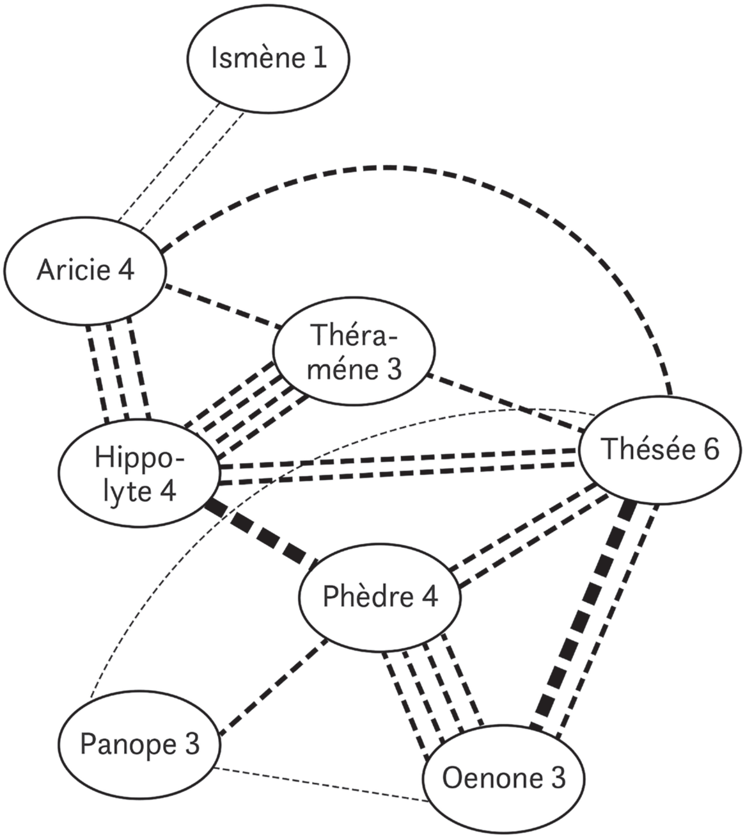

Fig. 3. Network of Jean Racine's *Phèdre*, a dramatic narrative. The number of arrows corresponds to the number of exchanges between the characters. The weight of the arrows suggests their dramatic importance. Numbers represent degrees of connectivity to other characters. Created by the author.

ters are strongly interrelated, except for some marginal confidante or messenger types, and the system of connections, rather than individual characters, is the heart of the plot. The degree of connectivity of a character node gives a rough idea of its importance for the plot, but this is not an absolutely reliable criterion, because this would make Thésée the main character of *Phèdre*. We also need to map the number of scenes in which characters interact with one another, as shown in figure 3. But a computer examining this network would again think that Thésée is more important than Phèdre, because the diagram makes no distinction between dramatically significant exchanges (such as the unique exchange between Phèdre and Hippolyte in which she confesses her love for him) and short, purely utilitarian exchanges where characters transmit news. While a computer could create the diagrams of figures 1 and 2, it takes human interpretation to create a diagram that shows the dramatic weight of exchanges, as I have tried to do in figure 3. This shows the limits of a computational approach to narrative complexity.

Still, plot diagrams based on interpersonal relations are not useless, because they can show a certain type of complexity, which can be used as the basis of a plot typology. By the standard of connectivity, the complexity of a plot is not a function of the number of characters or of events, but a matter of interconnection. The more difficult it is to cut out parts of the network, the more they contribute to a plot's complexity. For instance, it is easy to cut away the episodes of an it-narrative by severing one link. By this standard, the dramatic narrative is the most complex, followed by the epic narrative and the it-narrative.

The network diagram may tell about the complexity of the system of human relations that underlies a narrative, but it does not tell anything about the nature of the interactions that constitute the plot. For such a model, I propose to turn to the metaphor of the landscape introduced by Scott E. Page, a specialist of complex systems. Page distinguishes three kinds of landscapes, which correspond to three kinds of systems of increasing complexity (2009, 6–9). Imagine that with every type of landscape there is a problem to solve, the problem of finding the highest point in the landscape. Now keep in mind that virtually all narratives are about finding solutions to problems, if by the pair "problem/solution" one understands patterns such as the pursuit of desires, the fulfillment of obligations, the restauration of a broken equilibrium, or adaptation to changed circumstances.

The first type is a simple system represented by the shape of Mount Fuji. In this kind of system, it is very easy to find the highest peak in the landscape. In a narrative shaped like Mount Fuji, there is a problem with an obvious solution; this solution is adopted, and the story is not very interesting. An example would be a fox who is hungry. He buys a wheel of cheese, he eats it, and he is no longer hungry. An efficient solution but a boring narrative, because the system lacks complexity.

The second type of landscape is compared by Page (2009) to the profile of the Appalachian Mountains. It is a rugged landscape, made of many ridges, and it is much more difficult to find the highest peak than in a Mount Fuji landscape. In this kind of system there are conflicting goals. Page uses the example of an agent with conflicting personal goals (for instance, taking a job in a nice place versus taking a job that makes lots of money), so the optimal solution must involve compromise. But the idea of conflicting goals can also be applied to the case of many agents who have different personal goals. The solution of the main problem must take all these goals into consideration, whether it is through compromise, or—more frequently in narrative—through deceit or competition. In the case of deceit, some characters will be made to act against their own interests. Let's return to the case of the hungry fox. Rather than buying cheese, he notices a crow in a tree who holds a piece of cheese in his beak. The crow is also hungry, and he certainly won't part with the cheese voluntarily, so the two characters have incompatible goals. To get the cheese the fox must take the crow's desire to hold onto the cheese into consideration. So, rather than asking the crow to share it, he resorts to deceit. The conflict between the fox's and the crow's goals, and the ingenuity of the fox's solution, make the story a far more interesting narrative than the previous example, where the fox buys cheese.

The story of the fox and the crow may rest on a conflict between the goals of two characters, but the landscape is relatively stable: the goals do not change drastically during the story. In the third kind of landscape, the configuration of the system is highly unstable. Page (2009) calls it a "dancing landscape," and he compares it to a landscape that is being shaken by an earthquake, so its global state changes continuously and so does the highest peak. This kind of system contains multiple interdependent actors with various goals. Some characters pursue the same goals (so that they are in a helper relation); other characters have competing goals, and if one of them succeeds, another will fail. The global situation evolves throughout the narrative as the result of two types of events. The first type is external accidental events, such as an earthquake. Though these events are not under the control of characters, they have important consequences on their situation and interpersonal relations. The second type of events is intentional actions performed by the characters in the pursuit of their goals. As Page writes, "Interdependence between our actions and the actions of others are what makes a landscape dance" (8). In a dancing-landscape narrative, characters must adapt their behavior to a constantly changing situation.

Let me illustrate this idea with an analysis of *Phèdre*, a tragedy with a remarkably tight and logical plot, even if the actions of characters are anything but rational. The causal and temporal networks of Phèdre are shown on figure 4. Here is how the plot develops:

Situation 1: Thésée is king of Trézène. He is absent, but he holds power. Phèdre, his wife, secretly loves Hippolyte, Thésée's son by a previous marriage. This love is forbidden for two reasons: she is married, and he is her stepson. (Her love is considered incestuous by the standards of the play.) Hippolyte loves Aricie, and she loves him, but he cannot marry her because she comes from an enemy family.

Phèdre's adaptation to the situation: She decides to let herself die. But this decision is abandoned when an external event changes the whole situation: Thésée's death is announced.

Situation 2: An obstacle to Phèdre's and Hippolyte's respective loves is removed.

Phèdre's adaptation: She sees hope in her love for Hippolyte and confesses it to him, but he does not respond. This is a failed action.

Then another external event changes the landscape: it turns out that Thésée is not dead, and he returns to Trézène.

Situation 3: Phèdre feels dishonored by her confession and fears that Hippolyte will tell Thésée.

Phèdre's adaptation: She allows her nurse, Oenone, to tell Thésée that Hippolyte has tried to force himself on her.

Situation 4: Thésée believes Oenone.

Thésée's adaptation: He curses Hippolyte, banishes him from the kingdom, and asks the god Neptune to punish him.

Situation 5: Hippolyte learns of Thésée's curse.

Hippolyte adaptation to 5: He tries to show his innocence by telling Thésée of his love for Aricie, but, the gentleman that he is, he does not tell anything about Phèdre's love confession. Thésée does not believe him: this is a failed action.

Meanwhile, in **situation 6**, Phèdre feels guilty about the severity of Hippolyte's punishment; she decides to save him and to confess everything to Thésée. But in the course of the exchange Thésée inadvertently reveals to her that Hippolyte loves Aricie.

This accidental event leads to **situation 7**: Phèdre, who thought that Hippolyte was incapable of love, realizes that she has a rival, and she is furious.

Phèdre's adaptation to 7: She keeps silent about Oenone's lie, possibly causing Hippolyte's later death, for if he had learned the truth, Thésée could perhaps have done something to save him.

Meanwhile, in **situation 8**, Aricie is upset about the curse on Hippolyte, and she pleads Hippolyte's cause to Thésée.

This action leads to **situation 9**: Thésée begins to have doubts about the crime of Hippolyte.

He asks for the return of Hippolyte to question him.

But then Théramène arrives and announces that Hippolyte has been killed by a sea monster as a result of Thésée's curse. Théramène's arrival is an external event, but Hippolyte's death is not, because it is a result of Thésée's curse and Phèdre's silence.

This revelation leads to **situation 10**. Phèdre feels guilty of Hippolyte's death.

She confesses everything to Thésée, takes poison, and dies.

This action leads to **situation 11**: Thésée realizes Hippolyte's innocence.

To honor Hippolyte's memory, he adopts Aricie as a daughter.

For clarity's sake I have numbered the situations sequentially, and this corresponds to their order of occurrence in the play. One could pull the situations and the events that follow them directly into a line; however, one cannot pull the system of causal relations into a line, because it would form knots. The linear sequence of situations and events can be explained only by a nonlinear network of causal relations.

Let's take a closer look at why there are discrepancies between the temporal sequence and the causal network. On the level of story, narrative can be described as a linear succession of events that cause changes in a storyworld. But a world can contain many agents who act more or less simultaneously, creating the causal chains of parallel plot lines. A state can be the result of the accidental convergence of different plot lines: for instance, John goes to a party and drinks too much. On his

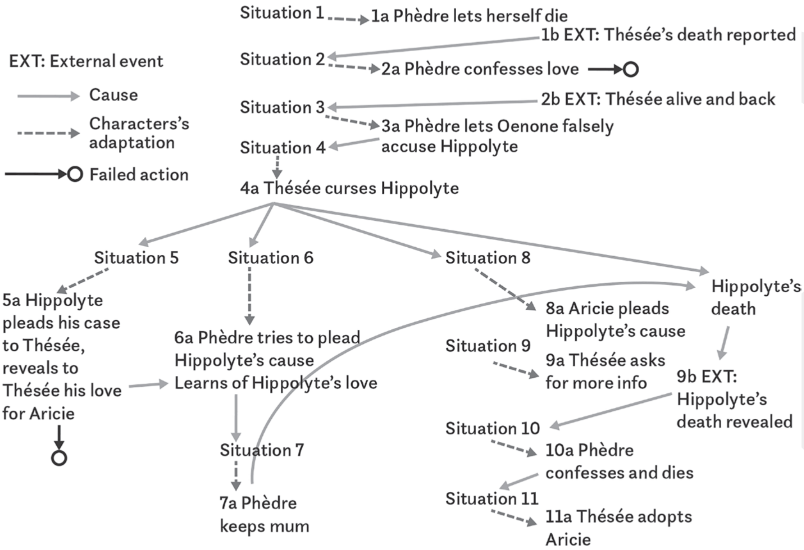

Fig. 4. Presentational sequence versus causal network for *Phèdre*. The presentational sequence is indicated by the numbering of events: 1a, 1b, 2a, 2b, 3a, 4a, and so on. The causal network consists of the causal relations between situations and the adaptive actions of characters. The content of situations is explained in the text. Created by the author.

drive home he hits Mary, who was walking her dog, and kills her. In this case the state "Mary is dead" is caused by the coincidence of two chains of events. Similarly, the death of Hippolyte in *Phèdre* is arguably the result of a double causality, Thésée's curse and Phèdre's silence about Oenone's lie. While a situation can have multiple causes, it can affect multiple agents in different ways and have multiple effects. In *Phèdre* we see Hippolyte, Phèdre, and Aricie reacting separately (though pretty much in the same way) to Thésée's curse. Quite often characters react to the same situation in opposite ways: what is good for the hero is bad for the villain, and while the hero basks in triumph the villain may be plotting a revenge. Finally, the effects of events may be delayed: for instance, Jason may be unable to marry Amanda because it is revealed that long ago his father had a secret affair, and Amanda is his half sister. In *Phèdre* Thésées's curse has a delayed effect, since several events intervene before Hippolyte is killed (at an indeterminate time and not onstage) by a sea monster. My claim, then, is that discrepancies between the temporal sequence and the causal network are a major factor of narrative complexity. Narratives are almost always linear in their presentation, since events must be represented by most media one after the other, but their plots can be highly nonlinear on the level of causal relations. The greater the discrepancy between the temporal sequence and the causal network, the more complex the plot.

Emergence

Emergence, in its strongest form, is a property of phenomena that we do not fully understand: how the individual elements of a system organize themselves into larger functional patterns without the top-down guidance of a controlling authority.[5] For instance, to say that consciousness emerges from the activity of individual neurons is another way of saying that we cannot bridge the gap between neuronal activity and (self-) conscious thought. What then does it mean to speak of narrative emergence, and can we say something meaningful about it?

Emergence can appear on two narrative levels: the level of content and the level of form. On the level of content, the play *Arcadia*, by Tom Stoppard (1993), deals explicitly with the issue of complex systems and therefore, more or less directly, with emergent phenomena. Emergence is not only discussed but also manifested in the playthrough the unpredictable network of sexual attraction that links the characters. But it does not take explicit reference to complexity theory for a narrative to illustrate the phenomenon of emergence. Every tale of machines revolting against their maker and taking over the world—from the Golem to Frankenstein's monster to *The Matrix*—is a tale of emergence, since the human-programmed machine develops abilities and goals that its creators could not foresee.

What would a genuinely emergent narrative—as opposed to a narrative of emergence—be like? We must remain in the domain of the fictional to find a working example: in Neal Stephenson's *The Diamond Age*, a novel about a poor girl in a repressive society who finds a magical (or rather, digital) book, the Primer, created by a computer wizard to educate a rich girl. The Primer tells a dynamic story that "ages" with the reader, adapting itself to her needs and becoming more and more sophisticated in style and plot as she grows older so that a single book can educate her from childhood into adulthood. On the technological level the Primer combines the distributed intelligence of the ant colony with the solidity of a well-connected network that will not be disabled when some links are broken. The smart paper of its pages is made of a billion microprocessors that aren't "especially smart or fast" and are very susceptible to being disabled, but "even with those limitations the smart paper still constituted . . . a very powerful graphical computer" (1996, 64).

The actual implementation of emergent narratives is infinitely more problematic than their fictional description. In my discussion of this issue I start with nonlinearity, a feature widely associated with emergence. In mathematics, nonlinearity is defined as the property of an equation that traces a curve rather than a straight line: any exponent higher than the number one will result in nonlinearity. Since one cannot produce narratives through equations (at least not yet), this definition is not useful to narratology. In complexity science, nonlinearity and its opposite, linearity, are defined in operational terms: "a linear system is one you can understand by understanding its parts individually and then putting them together" (Mitchell 2011, 22). For instance, the computation of the surface of the United States is a linear problem because it can be achieved by calculating the surface of every state and adding them together. A nonlinear system, by contrast, cannot be understood by looking at the properties of its basic elements, because it presents a hierarchical structure: individual elements group themselves into meaningful configurations on a higher level. For instance, we cannot describe the organization of the ant colony by describing the behavior of each ant, no more than we can pass directly from a certain configuration of excited neurons in the brain to the idea of a horse (Hofstadter 2007). According to this conception, language is nonlinear, since we don't interpret the sentence "the fox stole the cheese from the crow" by creating a dictionary with the entries "the," "fox," "steal, past tense," "cheese," and "crow." A proper interpretation would include a network showing a transfer of possession of the cheese from the crow to the fox as the result of a morally reprehensible action (but how does one show moral value on a network?). If language is nonlinear, narrative takes the property to a higher level, since it is not the sum of the meanings of its component sentences. Moreover, we don't understand a story by storing in memory a list of all the characters, objects, and events in the storyworld.

For nonlinearity to become a property of particular narratives, rather than a general feature, we must adopt a different definition, a definition that relies on the idea of sequentiality. Here, for instance, is how Espen Aarseth defines nonlinearity in his classic *Cybertext*: "A non-linear text is an object of verbal communication that is not simply one fixed sequence of letters, words, and sentences but one in which the words or sequences of words may differ from reading to reading because of the shape, conventions, or mechanisms of the text" (1997, 41).[6] According to Aarseth this property of nonlinearity appears in certain print texts that allow some freedom of choice ("Choose Your Own Adventure" stories, the *I Ching*, Vladimir Nabokov's *Pale Fire*, Julio Cortázar's *Rayuela*), but it is in digital texts (computer games, hypertext fiction) that it reaches its full potential because of the ability of the computer to let the user determine the sequence.

In the early days of digital textuality, the advocates of hypertext fiction regarded linearity as a limiting structure from which narrative should be liberated. George Landow (1997) promoted hypertext as the implementation of a mode of writing that Roland Barthes called "the writerly." Barthes conceived the writerly as a nonlinear "galaxy of signifiers" that could be entered in multiple ways and explored through multiple chains of associations; yet he regarded the plurality of the writerly as incompatible with narrativity: "for the plural text, there cannot be a narrative structure, a grammar or a logic; thus, if one or another of these are sometimes permitted to come forward, it is *in proportion* (giving this expression its full quantitative value) as we are dealing with incompletely plural texts, texts whose plural is more or less parsimonious" (1974, 5, 6; see discussion in Ryan 2016). It is easy to see why narrativity conflicts with nonlinearity: on the story level, narrative is a temporally ordered series of states, mediated by events that cause changes in the storyworld. Time, unlike space, is unidimensional and consequently linear. Causality, the glue that holds states and events together, adds unidirectionality to the sequence, since causes must precede their effects. How then can hypertext reconcile the inherent linearity of narrative meaning with a relative freedom of navigation through the text?

Hypertext narrative can be conceptualized in two ways: spatial or temporal. In the spatial conception there is a storyworld in which a certain sequence of events happens. The user's actions determine the order of presentation of the text, but they do not determine the temporal succession of events in the storyworld. The text is like a "garden of forking paths" (title of a short story by Borges often invoked in hypertext theory) that allows a large number of itineraries, some long, some short, but it is always the same garden, containing the same story that the user explores more or less fully. The spatial model maintains narrative coherence, even when causes are discovered after their effect, because it allows the reader to mentally rearrange elements in a proper chronological sequence. But the freedom of navigation prevents effects that rely on a fixed temporal disclosure of information, such as suspense and surprise.

In the temporal model, by contrast, the order in which readers discover elements corresponds to their chronological order in the storyworld. The reader who reaches A and then B reads a different story than the reader who reads B and then A, and these two readers "produce" different storyworlds. In contrast to the spatial model, the temporal model is supposed to yield many different stories, but when the underlying network is densely connected, the author cannot control the long-term succession of elements, and there is no guarantee of logical coherence. For every traversal to result in a well-formed story, the underlying network should be a tree, because in a tree structure, there are no circuits and consequently only one way to reach a certain node. The danger of encountering the effect before the cause is therefore eliminated. For this reason, the only working examples of the temporal structure are the tree-based "Choose Your Own Adventure" children stories (Ryan 2001). But with a story tree the individual stories are predetermined by the author; they are limited in number and length (they stop when the reader reaches the end of a branch), and there is consequently no real emergence, though children who identify with the hero may imagine that the story develops in real time as the result of their decisions. In the spatial model, by contrast, the number of paths through the text is unlimited, and emergence takes place in the many ways of experiencing the narrative discourse.

For a text to present emergence on the level of story, a sequence of events must be generated during the live performance of the text or during the run of the program that operates it, and different performances or runs should produce different stories. As Richard Walsh observes, the best available model for emergent narrative is dramatic improvisation, as found in commedia dell'arte: "The story produced by a group of improvising actors is not determined top-down, by a playwright or director, nor is it the creation of one actor. Instead, it emerges from the interaction among the members of the group—that is, the elements of the system" (2011, 76). However, the spectator is external to the performance, and, while knowing that the actors are improvising enhances aesthetic appreciation, it does not lead to greater immersion or participation. For emergence to reach its fullest manifestation, the user must be part of the system, so as to have a say in the development of the story. In other words, the system must be interactive.

Whereas in hypertext the algorithm does no more than guide the user through a database of prewritten textual fragments, in more "intelligent" types of digital narratives, such as video games, interactive drama, or automated storytelling program, the computer generates stories by performing a simulation of the storyworld. By simulation I mean that the computer keeps track of the state of the storyworld, allowing only those actions that are relevant to the current state and updating the world's state on the basis of the user's choices (or on the basis of a random choice among several possible alternatives). The system "knows" to some extent what is going on, in contrast to hypertext, where sense making is entirely left to the user. In a simulation different choices at the decision points will result in different sequences of states and events, this is to say, in different stories.[7]

Yet the narrativity of the output of a simulator is far from being universally recognized by those who have given thoughts to the issue. To understand why, we must go back to the definition of simulation proposed by Gonzalo Frasca, one of the pioneers of computer-game studies. According to Frasca, "to simulate is to model a (source) system through a different system which maintains to somebody some of the behaviors of the original system" (2003, 223). While in the conception previously outlined, simulation can create imaginary worlds and processes, Frasca's definition presents simulations as models of existent systems, such as flying an airplane.[8] There is consequently no way a fictional story can be regarded as the product of a simulation engine. Another of Frasca's reasons for regarding simulation as incompatible with narrative is explained by Walsh, who agrees with Frasca on this point: "Simulation and narration, as modes of representation, are different in kind: a simulation represents a system, globally, while a narrative represents a discrete tempo-

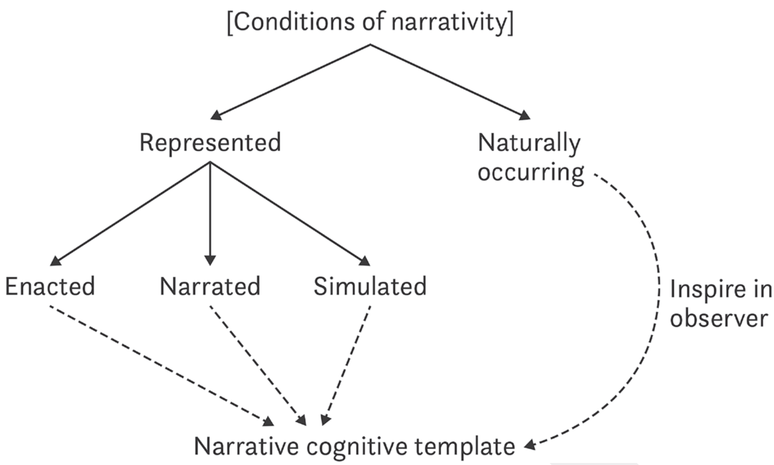

Fig. 5. Modes of realization of narrativity. Created by the author.

ral sequence" (2011, 78). A flight simulator can indeed represent all the flights that can happen with a certain airplane, while a standard narration (print novel, comic, and movie) can represent only one particular flight. But rather than driving a wedge between simulation and narration, why not regard narration and simulation as two ways to communicate a certain type of semantic material that fulfills the basic conditions of narrativity? There are at least three ways to represent narrative content: enactment, as in drama and film; narration, as in novels; and simulation, as in computer games and story generators (figure 5). While narration produces only one story, and the multiple live enactments of the theater (as opposed to the single enactment of film) produce only small variations on a common script, simulation generates many stories, thereby fulfilling the basic condition of emergence.

It could, however, be argued that the various runs of a computer game do not "tell" any story since they have no narrator nor narration.[9] But neither do film and drama, except in the case of voiced-over narration. This is why for a long time these media have been excluded from narratology. To solve the problem of the narrativity of simulations and restore the possibility of narrative emergence in digital media, I propose to invoke the distinction I made in Ryan (2004) between "being a narrative" and "having narrativity." Even when they do not explicitly "tell" stories, simulative engines can produce outputs that activate in the player's mind the cognitive template that defines narrativity, just as certain life situations activate this template in the mind of the observer or participant. Whether it happens in the real world or in a fictional world, a situation contemplated by a mind can have narrativity without being a narrative, this is to say, without being encoded in a discourse that explicitly narrates past events.

This does not mean that the narratives of simulation-driven games are necessarily emergent. On the contrary, most computer games implement a predefined story, and variation occurs only on the microlevel, the level of how the player passes from fixed point A to fixed point B. The actions performed by players to solve individual problems can be said to possess narrativity, because it is by telling a story about them that players brag to other players about their exploits in the game world. They also possess some degree of emergence, because every player will perform a slightly different set of actions. But these moments of narrative emergence are framed by invariable events implemented by the code. Playing the game thus means progressing along a fixed plot line. Genuine narrative emergence, by contrast, requires the real-time generation of a sequence of events that the user or interactor will interpret narratively, and these events must not be foreseen by the designer.

Perhaps the most successful step in this direction is the computer game *The Sims* (2000–14). The name of the game indicates the importance of simulation in the algorithm that runs it: the game constructs a world; fills it with objects and characters; specifies their properties and affordances; gives aspirations, fears and goals to the characters; and proposes to the player menus of actions that characters can perform in a given situation. After an action has been performed, the system calculates its effects, not only on the physical world, but also on the inner world of the characters and on their personal relations. For instance, if Lisa tries to kiss Tina, this will affect Tina's feelings toward Lisa either positively or negatively, depending on how her personality has been set up by the code. Following the advice of Sandy Louchard and colleagues (2015, 186) to let emergent narratives be driven by characters rather than by plot (for plots are preset story arcs: how could they be emergent?), the game's basic idea consists of throwing a number of characters (a group of friends or a family) with strong but distinct personalities in a common arena (a house or neighborhood) and letting them interact with one another so that a narratable sequence of events will emerge from their actions, fueled by their individual aspirations. Players can either select actions randomly, to see what the system will do, or try to implement certain narrative patterns, such as Greg getting rich, buying a fancy house, and successfully courting Jen. (The getting-rich narrative is the game's implicit script, but it can be subverted.) Because the range of possible actions in a given situation is always determined by the code, players are never in total control of the narrative development, but neither is the system. When the code throws in events, such as death claiming a character, it plays the role of blind fate, rather than trying to implement a script. Through its combination of goal-oriented action and random happenings, *The Sims* is a credible simulation of life. On the negative side the game has been blamed for giving far too much importance to the repetitive chores of daily life (this is not drama, this is housekeeping, complained Chris Crawford [2004]) and for being unable to produce narrative closure: *The Sims* is a system for never-ending soap operas, not for stories with a dramatic arc.

Let me conclude this section by asking whether or not interactivity is a necessary feature of emergent narrative. If interactivity means dynamic relations between the elements of the system, which means between the characters, then the answer is definitely yes, but this is a feature of all narratives. On the other hand, if interactivity means the user's ability to control the system, either by manipulating characters from a godlike perspective (as in *The Sims*) or by impersonating one of them, then the answer is a cautious no, because there are, or could be, simulation-based story-generating programs that churn out different stories without external intervention, such as James Meehan's *Tale-Spin* (1981), Scott Turner's *MINSTREL* (1984), or Selmer Bringsjord and David Ferrucci's *Brutus* (1999). Yet the number of different stories that these systems generate is very limited (often no more than half a dozen, though huge numbers of lines of code are needed to produce them), and none of them is worth reading for pleasure. Artificial intelligence has made tremendous advances in the past few years in many domains, but automated story generation is not one of them.

While noninteractive but emergent narrative systems are at least conceivable, user interactivity is a strong factor of emergence, because it injects systems with variable information and therefore guarantees that different runs of the program will produce different outputs. But the combination of interactivity and narrativity is the greatest problem that faces designers of digital art and entertainment, because narrative, as a global pattern, requires top-down control, while interactivity provides bottom-up input. Computer scientists Ruth Aylett and Sandy Louchard call this situation the interactive paradox: "On the one hand the author seeks control over the direction of a narrative in order to give it a satisfactory structure. On the other hand a participating user demands the autonomy to act and react without explicit authorial constraint" (2004, 25). If the task of generating reasonably interesting noninteractive stories is already beyond the ability of current AI, the difficulty of the task is elevated to a higher power if the stories have to incorporate unpredictable user input. It is only by limiting the range of choices of the user (for instance, by proposing a menu of possible actions) that a compromise can be achieved between interactivity and narrativity, but this limitation presupposes a predetermined global narrative script. As the user's freedom is restricted, so is the system's degree of narrative emergence. Since 2000 intensive work has been devoted to the creation of interactive narrative, but the formula that would ensure a successful compromise between the top-down design of narrative and the bottom-up input of the user still eludes designers.[10] To this day, with the possible exception of *The Sims*, there is no commercially viable system that produces truly emergent interactive narratives.

But who says that emergent narrative has to be computer assisted? Artificial intelligence has yet to approach human intelligence in narrative creativity, so why not rely on natural intelligence to adapt character behavior to unpredictable, evolving situations? In tabletop role-playing games (Caïra and Tosca 2014), a naturally intelligent game master coordinates the behavior of a group of players who impersonate the characters of a partly predefined, partly improvised narrative script described in a rule book. Here is how tabletop games work: Using storytelling skills and relying on the rule book, the game master describes the current situation of the game world and the actions that can be taken in this particular situation. The players choose an action and roll a dice to determine its outcome. The game master narrates the event, and a new situation is created, allowing new actions. Creative game masters can make new rules on the fly when the players take the story in an unforeseen direction; they can overrule the book when they can imagine more exciting developments; and they encourage the players to act out their roles by improvising dialogue. Tabletop role-playing games are commedia dell'arte without spectators, since the beneficiaries of the performance are integrated into the storyworld. But a more emergent narrative does not necessarily mean a better, more satisfying narrative. Many people prefer to watch and read a totally prescripted story than to participate actively in an emergent narrative.

Conclusion

Let me return to the question of whether complexity is a universal feature of narratives or a distinctive property, that is, a property that creates distinctions within the set of all stories. In systems theory complexity is considered distinctive rather than universal: there are simple systems whose behavior can be predicted by a fixed formula, and complex systems whose behavior can be described only by applying their rules over and over again, just as there are stable landscapes that look like Mount Fuji, and dancing landscapes whose highest points continually change. In narrative matters the answer depends on how one conceives complexity. Here I have given two particular interpretations inspired by complexity science, namely, complexity as lack of a central controlling unit and complexity as emergence, but even these two ideas can be interpreted in many different ways. Emergence, for instance, can be conceived as the dynamic unfolding of narrative meaning through time (e.g. Walsh 2011), which makes it a universal property, since there cannot be narratives without a world undergoing changes, and there cannot be changes without a temporal frame; but this property is shared by all temporal arts and therefore does not say anything specific about narrativity. Emergence could also be conceived as unpredictability, which means the ability of a plot to create surprise, but this would not make it a distinctive property, since there are narratives whose ending is entirely predictable. In this chapter I have interpreted emergence as the ability of some systems to produce multiple stories. This property is scalar and distinctive, at least when story is taken literally and in a strong sense, since most narrative texts are not generative (Aarseth 1997 would say ergodic) systems with multiple outputs.[11] The lack of a central controlling unit on the level of story, by contrast, can be regarded as typical of all narratives, even of narratives with a clearly central character, since no character absolutely controls the world, not even God, for God has to put up with the forces of evil. (Without such forces there would be no narrative.) The lack of a central controlling unit can lead to plots of variable complexity, depending on the number of characters, the compatibility of their desires, their ability to adapt to changing circumstances, and, above all, whether the causal system follows the temporal sequence or creates knots that tie together nonadjacent situations.

Notes

1. John Horgan (1995) compares complexity theory to other, mostly short-lived twentieth-century scientific movements such as cybernetics (Norbert Wiener), catastrophe theory (René Thom), information theory (Claude Shannon), and the predecessor of complexity, chaos theory. One may also place in this category Stephen Wolfram's New Kind of Science, based on cellular automata. According to Horgan, most of these movements were the brainchild of one individual who envisioned the expansion of an idea into a "theory of everything." For a rejoinder, see Mitchell (2011, 292–303).
2. By regarding plot as a decentralized system, I challenge the claim made by H. Porter Abbott in "Narrative and Emergent Behavior." Abbott argues that evolution, the prototype of emergent processes, cannot be narrated, because narrative is concerned with a central controlling instance, while evolution results from many "blind" microprocesses. He regards narratives of central control (such as explaining evolution through intelligent design or history through theories of conspiracy) as reassuring because they attribute an identifiable, unique cause to phenomena and "allow the perceiver to achieve a sense of cognitive control" (2008, 239). Abbott admits, however, that central control is not a necessary feature of narrative: "Canonical narratives like *Hamlet* generally resist the reduction to some form of central control, and long novels like Eliot's *Middlemarch*, Mann's *Buddenbrooks*, and Proust's *A la Recherche du Temps Perdu* are monuments of such narrative complexity. But even soap operas can be mightily complex as well" (232). In my view this claim does not go far enough: even simple stories, such as "Little Red Riding Hood," do not normally explain events through a central controlling instance, as do so-called grand narratives. In most stories causality, from which narrative derives its explanatory power, works only between individual events. It would take a grand narrative to try to explain why the whole chain of events happened at all. Still, I agree with

Abbott that evolution does not lend itself to narrativization, because of the lack of deliberate agents. Pure randomness does not make good stories.

3. Maria Poulaki (2014) (following Bordwell 2006) discusses one type of story as "network narrative": a story exhibiting a "small world" pattern (a favorite concept of complexity science), where a large number of characters belonging to different groups are suddenly connected through random, external events. Her example is the 2008 film *Burn after Reading*. Here, however, I argue that all narratives are built on a network structure, though in the simplest cases this network may be linear. (A series of nodes connected to one another by a single edge is still a network.)
4. What about characters who appear in several episodes? Since the diagram shows character-to-character relations, but not the number of interactions, once characters are linked to the hero, they may appear many times in the plot.
5. This mysterious nature of emergence could explain why H. Porter Abbott (2004, 2008) regards emergent phenomena as unnarratable, since narration, to a large part, is explanation.
6. Actually, there is no need to restrict the definition to verbal communication.
7. The term *simulation* is also widely used to designate the mental modeling of storyworlds that takes place in the minds of readers, spectators, and players as they go through a narrative text. This kind of simulation is a fundamental condition of narrative comprehension.
8. By this criterion computer games can be regarded as simulations only on the microlevel of individual actions, such as shooting, driving cars, and collecting objects.
9. An exception is provided by those games in which a narrator, or announcer character, describes the events that happen in the game as the result of the player's actions. This feature is found in sports games and also in some massively multiplayer online role-playing games such as *EverQuest*. Story-generating programs such as *Tale-Spin* (Meehan 1981) also combine simulation with narration by narrating what they produce through simulation. These examples provide an argument against Frasca's (2003) claim that simulation and narration are mutually incompatible modes of representation.
10. This work is pursued by organizations such as ICIDS (International Conference for Interactive Digital Narrative), CMN (Computational Models of Narrative), or a branch of AAAI (Association for the Advancement of Artificial Intelligence) devoted to "narrative intelligence."
11. In a weak sense one could say that every narrative text generates multiple readings, hence multiple stories.

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