Narrative Revolution: The Nonlinear Logic from Hypertext to Interactive Images

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Abstract: For over two millennia, Aristotle's theory of mimesis has dominated the Western tradition of linear narrative, rooted in humanity's early linear cognition of nature through sequential storytelling. However, 20th-century nonlinear science revealed the intrinsic nonlinear characteristics of reality, subverting this perception and posing a core question for art: How to narrativize complex nonlinear reality?

This interdisciplinary study employs core nonlinear scientific theories (chaos theory, fractal theory, soliton theory, dissipative structure theory) as analytical tools to trace the evolutionary journey of narrative from literary hypertext to contemporary interactive images.

The research reveals that nonlinear narrative is not merely a formal experiment but an inevitable manifestation of a scientific-philosophical paradigm shift. Its key manifestations—plot folding, recursive structures, and synergistic resonance —represent aesthetic simulations of world complexity. As the current pinnacle of nonlinear narrative, interactive images resolve the dilemmas of early forms (hypertext fiction, branching cinema) through technological means, achieving profound integration of science and art at the level of "complexity."

Keywords: Nonlinear Narrative; Hypertext; Interactive Images; Narrative Revolution; Nonlinear Logic

1. Introduction: Linear Hegemony and Nonlinear Turn

1.1 The Legacy of Mimesis

For over two millennia, Aristotle's concept of mimesis has secured the dominant position of linear paradigms within Western narrative traditions.This worldview, which regards art as "imitating reality" through temporally complete stories, is not merely an aesthetic choice but a reflection of humanity's early cognitive framework—an approach to parsing nature through sequential causality. Just as Ptolemaic astronomy once mapped the universe as a series of concentric circles, linear narrative also endows existence with reassuring order, simplifying fluid experience into a graspable "beginning-development-ending" structure. The enduring vitality of this tradition attests to its practicality: it provides a shared cognitive language for understanding the world while subtly masking the inherent chaos and complexity of reality itself. As mathematician Gu Chaohao later noted, this linear bias stands in stark contrast to the intrinsic nature of the universe—a contradiction that would ultimately shake the foundations of narrative.

1.2 The Constructed Nature of Time

The core of linear hegemony lies in shaping time as a universal, objective measuring standard. In reality, time is essentially a cognitive coordinate system—a tool created by humans to simplify reality into navigable sequences. Just as a straight ruler approximates a winding path, linear time ensures narrative coherence at the cost of dimensional reduction. This simplification is both practical and problematic: it enables storytelling while filtering out the complex, recursive, and emergent qualities of lived experience. This generates a core paradox: humanity has long relied on linear tools to describe a nonlinear world. The field of population studies offers a telling example: Malthus's exponential-growth model consistently failed to capture reality's complexity until the nonlinear logistic equation corrected it; likewise, linear narrative continuously "truncates" reality. Nonlinear science later exposed this limitation—whether in weather systems or human life,

minute disturbances in initial conditions can trigger drastically different outcomes, shattering the illusion of deterministic order.

1.3 Scientific Paradigm Shift

The rise of 20th-century nonlinear science broke this cognitive inertia, becoming the "third scientific revolution" after relativity and quantum mechanics. This interdisciplinary breakthrough encompasses chaos theory, fractal theory, soliton theory, and dissipative structure theory, discovering universal laws across seemingly unrelated fields such as physics, biology, and sociology. As nonlinear science researcher Li Shiyong noted, nonlinear theories possess "universality," providing a common language for understanding complexity across disciplines. Concepts like the "butterfly effect" (chaos theory), "self-similarity" (fractal theory), and "open system dynamics" (dissipative structure theory) not only revolutionized scientific thinking but also posed profound questions for the humanities: If reality is inherently nonlinear, how should narrative evolve to represent this essence? These theories not only offer new perspectives on the world but also provide methodologies for artistic innovation, spawning narrative forms that embrace ambiguity, recursiveness, and connectivity.

1.4 Research Framework

This paper explores how narrative responds to this scientific paradigm shift, tracing the evolutionary trajectory of nonlinear narrative from early literary hypertext to contemporary interactive images. Through the analytical lens of nonlinear scientific philosophy, this study investigates how core narrative manifestations—such as plot folding (corresponding to chaos theory), recursive structures (corresponding to fractal theory), and synergistic resonance (corresponding to synergetics)—serve as aesthetic transformations of complex systems theory. Specifically, this paper examines how interactive images/video, as the most advanced form of nonlinear narrative, address the dilemmas of earlier carriers (hypertext fiction, branching cinema) through technological innovation. In doing so, this research reveals the deepening integration of science and art in their shared pursuit of "representing complexity."

2. Theoretical Framework: The Grammar of Complexity

This section translates core nonlinear scientific theories into analytical tools applicable to interactive narratives (interactive films, games), focusing on how technological interaction enhances the alignment between scientific logic and narrative expression.

2.1 Soliton Theory： Stability and Permeability of Narrative Units

Solitons are stable, self-sustaining "particles" in nonlinear systems that maintain their integrity while interacting with other units (Russell, 1834).

"Narrative solitons"—stable, unalterable core elements in interactive narratives, such as the fixed motivation of "saving loved ones" in Heavy Rain, the central image of the "time-looping watch" in 12 Minutes, and independent plot modules like character backstory chapters in Life Is Strange. Regardless of user choices, these units maintain coherence while permeating other narrative branches through "decision nodes."

In the interactive film Black Mirror: Bandersnatch, the "career choice" (becoming a game developer/novelist) serves as a quintessential narrative soliton. Although user choices direct the main plot toward different directions, the core of each branch—the struggle over creative control—remains constant. Furthermore, these solitons interact: choosing to "hack the system" in the "game developer" branch connects to content from the "novelist conspiracy" branch, creating cross-unit resonance without compromising individual soliton integrity. This design externalizes "permeability" through interactivity, placing it under user control to resolve the "fragmentation risk" of traditional multilinear narrative.

2.2 Chaos Theory and Strange Attractors： Deterministic Constraints on Randomness

Chaos theory describes seemingly random phenomena in deterministic systems, with "strange attractors" confining system trajectories within meaningful limits (Lorenz, 1963).

"Narrative attractors"—implicit constraints that anchor interactive plots, such as the central theme of "free will vs. determinism" in Detroit: Become Human, the unsolved mystery of the "Origami Killer's identity" in Heavy Rain, and the fixed emotional tone of "grief and redemption" in Gris. User choices (the "butterfly effect") generate branch randomness, yet all paths ultimately converge on outcomes shaped by these attractors.

In The Witcher 3: Wild Hunt ("Blood and Wine" DLC), user decisions—"spare/kill vampire Regis" and "support nobles/peasants"—produce dozens of plot variations. However, "Geralt's code of honor" as a "strange attractor" consistently constrains all endings: even if users choose violent options, the narrative reflects Geralt's core values through consequences (such as Regis leaving), avoiding moral nihilism. This aligns with Lorenz's "strange attractor" logic: interactivity generates chaos, while attractors ensure narrative meaning does not descend into meaningless randomness.

2.3 Dissipative Structure Theory： Narrative Openness and Meaning Generation

Dissipative structures are open systems that maintain order through energy exchange ("negative entropy") with the external environment (Prigogine, 1969).

"Interactive dissipative narrative"—frames interactive narrative as a system dependent on user input (negative entropy) to avoid stagnation. Without user engagement (such as decisions, exploration, interpretation), narrative remains static "text"; with user input, it evolves into a dynamic, meaning-rich "experience."

The game Elden Ring exemplifies this logic. Its foundational narrative—"reunite the Elden Ring and become Elden Lord"—serves as a static framework, but user interactions (such as allying with the "Ranni the Witch" faction or interpreting the "Golden Order" as oppressive) inject negative entropy. Players share theories online (e.g., "the Erdtree is a prison"), collectively constructing meaning and preventing narrative confinement to a single authorial interpretation. Unlike the "predefined meaning" of linear films, interactive narrative as a dissipative structure derives vitality from continuous exchange with users.

2.4 Catastrophe Theory： Narrative Critical Points and Transitions

Catastrophe theory describes discontinuous sudden state changes in systems, where such changes depend on the gradual accumulation of "control parameters" (Thom, 1972).

"Interactive catastrophe nodes"—decision points in interactive narratives where a single choice triggers sudden plot transitions, premised on the gradual accumulation of'control parameters'(such as character relationships, plot foreshadowing).

In the interactive film Late Shift, the pivotal choice to "help the thief escape / betray the thief" triggers a catastrophic bifurcation: betrayal instantly initiates a police chase, while assistance opens a robbery arc. The switch is not arbitrary: earlier choices—such as "lying to the police" or "accepting the thief's bribe"—function as control parameters that gradually construct the protagonist's moral disposition. Opting for betrayal without sufficient moral groundwork feels jarring, confirming that interactive "catastrophes" demand cumulative preparation, exactly as René Thom's theory predicts. By tying narrative transitions to user-driven parameter accretion, the design sidesteps the "forced twist" problem endemic to traditional cinema.

2.5 Fractal Theory： Structural Self-Similarity and Scale Recursiveness

Fractals exhibit self-similarity—microstructures mirror macro patterns across different scales (Mandelbrot, 1975).

"Narrative fractals"—characteristics where microelements (side quests, character dialogues) mirror macro themes or structures (main plot, core ideology) in interactive narratives.

The Legend of Zelda: Breath of the Wild employs narrative fractals. Its macro goal—"defeat Calamity Ganon and save Hyrule"—follows the structure: "identify threat (Divine Beast) : solve puzzles to weaken threat : confront leader." This structure recurs in micro side quests, such as "save village from monsters : gather resources : defeat monsters," and even smaller interactions (like "help farmer retrieve horse") follow the "problem-solution" pattern. This self-similarity deepens user immersion: mastering micro challenges prepares for macro objectives, consistent with Mandelbrot's fractal logic—contrasting with traditional films where micro and macro structures rarely intersect.

2.6 Synergetics : Competition and Collaboration in Multithreading

Synergetics studies competition and collaboration among subsystems (threads), with "order parameters" (dominant factors) driving systems toward order (Haken, 1976).

"Interactive order parameters"—dominant themes or goals that coordinate multiple interactive narrative threads, resolving inter-branch competition and ensuring macro coherence.

Mass Effect 2 features three competing threads: "recruiting team members," "gathering resources for the final mission," and "managing internal team conflicts." The "order parameter" of "surviving the suicide mission" forces thread collaboration: neglecting any thread (e.g., skipping loyalty missions) results in character deaths, while balancing all threads ensures mission success. Interactivity lets users witness synergy in real time: choosing to "mediate the conflict between Garrus and Tali" (collaboration) strengthens squad cohesion, whereas ignoring the clash (competition) erodes it. Unlike traditional cinema—where thread coordination is dictated by editing—interactive narrative allows users to feel how order parameters sculpt subsystem dynamics.

3. Case Evolution: From Hypertext to Interactive Images

This section traces the evolutionary trajectory of nonlinear narrative carriers, analyzing how each generation responded to theoretical demands for complexity, addressed unique dilemmas, and ultimately progressed toward the mature form of contemporary interactive images.

3.1 Early Explorations: Dilemmas and Attempts in Hypertext Literature

Hypertext literature emerging in the 1980s represented the first conscious attempt to break linear narrative constraints. Its core innovation lay in translating nonlinear scientific logic into textual interaction, yet it failed to overcome practical limitations due to early digital technology constraints.

Hailed as the "paradigm of hypertext fiction," Afternoon abandoned linear "page-turning" in favor of a network of 529 text nodes connected by over 900 links. Opening with the ambiguous sentence "I want to say I may have seen my son die this afternoon," readers piece together meaning through navigating nodes (e.g., "memories of the accident," "conversations with ex-wife")—no two readers follow identical paths.

Self-similar link structures. The text's micro link system mirrors its macro narrative framework, embodying Mandelbrot's "fractal self-similarity." Each node (micro level) functions as a small narrative unit with branching links (e.g., the "accident" node divides into "police report," "witness memory," "personal guilt"), while the entire text (macro level) forms a recursive network of "memory fragments." This structure replicates fractal cross-scale consistency, allowing readers to grasp local meaning from any node while perceiving overall complexity.

Unpredictable reading paths. Abundant links generate "butterfly effect" uncertainty—choosing

a minor link (e.g., "skipping ex-wife's dialogue") might lead to drastically different narrative fragments (e.g., never discovering the son's survival).Consistent with Lorenz's chaos theory, minute differences in initial choices—the initial conditions—launch divergent trajectories, rendering the narrative's final form inherently unpredictable.

3.2 Transitional Attempts: Multipath Experiments in Branching Cinema

Branching films from the 1990s to early 2000s (e.g., Run Lola Run, Sliding Doors) inherited hypertext's nonlinear aspirations but simplified structures to prevent viewer disorientation. These works tested chaos and catastrophe theories through cinematic language (time loops, parallel universes) yet remained constrained by "director-dominated order parameters."

Run Lola Run: Lola must secure 100,000 marks within 20 minutes to save her boyfriend Manni from gang retaliation. The film repeats three "time loops," each leading to drastically different outcomes (Manni dies, Lola dies, both survive) due to minute differences in initial choices (e.g., whether Lola trips over a dog).

Sliding Doors: The critical choice of Helen "missing/catching the subway" splits the narrative into two parallel timelines—one where she discovers her boyfriend's infidelity, and another where she remains unaware.

Predefined multiple endings. The films' "parallel timelines" exhibit controlled chaos. Unlike hypertext's unbounded randomness, each timeline follows deterministic logic (e.g., Lola's speed determines whether she reaches the bank on time), with endings limited to 2-3 options. This aligns with Lorenz's "strange attractor" principle: chaos remains constrained by implicit boundaries (director's plot design), preventing narrative descent into disorder.

Discontinuous critical points."Time loop triggers"(Lola's scream) and"subway door closing"(Helen's choice) represent Thom's "catastrophe nodes." Activation of these nodes depends on gradual accumulation of "control parameters": the first two failed loops in Run Lola Run build emotional tension and plot context, making the third loop's success ("transition") plausible. Without such accumulation (e.g., opening directly with the successful loop), the ending would feel abrupt—violating catastrophe theory's "gradual accumulation： sudden transition" logic.

The films' multipaths suffer from Haken's "synergetic imbalance":Paths are entirely determined by pre-editing, leaving viewers unable to influence choices (e.g., preventing Lola from robbing a bank instead of asking her father for help). The "order parameter" (director's exploration of "chance vs. fate") dominates completely, reducing timelines (subsystems) to passively competing elements rather than collaborative agents.Despite multiple timelines, the director's ideological stance (e.g., "effort can change fate" in Run Lola Run) remains unshakable. This lack of user-system collaboration fails to achieve synergetics' core—emerging new order through subsystem interaction.

3.3 Contemporary Paradigm: Mature Form of Interactive Images

Contemporary interactive images since the 2010s (represented by Black Mirror: Bandersnatch and Detroit: Become Human) have constructed unified systems by integrating all nonlinear theories, resolving predecessors' dilemmas. They balance openness (dissipative structures) with constraints (strange attractors) and agency (synergy), achieving scientific-artistic harmony at the "complexity" level.

Black Mirror: Bandersnatch: Set in 1984, viewers control young game developer Stefan adapting a "choice-driven" novel into a game. Choices range from trivial (e.g., "Stefan eats cereal/toast") to life-or-death (e.g., "kill father/commit suicide"), featuring 5 main endings and over 120 minor variations.

Detroit: Become Human: Players control three androids (Connor, Kara, Markus) in dystopian

Detroit, shaping their stances through choices (e.g., "Connor obeys humans/joins android faction," "Kara protects girl Alice/abandons her") and determining the android revolution's fate (4 core endings: android extinction, human-machine coexistence, etc.).

Unlike hypertext's fixed links, user choices here represent "dynamic energy exchange." In Detroit: Become Human, choosing Markus to "negotiate with humans/lead violent protests" injects unique negative entropy—each choice alters character relationships (e.g., Kara gaining Alice's trust) and unlocks new plot modules (e.g., secret android sanctuary). Online communities amplify this exchange: players share "hidden endings" (e.g., Connor becoming android leader) and collectively interpret ambiguous plots (e.g., "whether Alice is human"), keeping the narrative system dynamic and avoiding entropy-induced stagnation.

Central themes function as "narrative attractors" constraining chaos. In Black Mirror: Bandersnatch, the attractor of "illusion of free will" unifies all choices—even if viewers choose "Stefan rebels against the director," the narrative frames it as part of the "free will illusion," pulling divergent paths back to the thematic framework. Similarly, Detroit: Become Human's "what it means to be human" attractor ensures even trivial choices (e.g., Connor saving a child) reinforce the macro theme. Consistent with Lorenz's "strange attractor" logic, paths maintain chaotic properties while never straying from the thematic "topological space," resolving hypertext's "disorientation dilemma."

These works realize Haken's synergetic vision—micro user choices (subsystems) and macro director themes (order parameters) both compete and collaborate. In Black Mirror: Bandersnatch, viewers feel "in control of Stefan's fate" (agency) while their choices remain subtly "subordinate" to themes (e.g., choosing "Stefan abandons game development" leads to a bland ending, prompting viewers to restart and align with the "creative obsession" theme). This balance resolves branching cinema's "passive viewing" flaw: users gain meaningful agency while narratives maintain structural coherence.

3.4 Resolution of Predecessor Dilemmas

Dilemmas of Early Carriers	Solutions in Interactive Images
Hypertext's "disorientation problem"	Guidance through "strange attractors" (themes/plot anchors) and interactive prompts (e.g., "this choice affects the outcome."), reducing entropy increase
Branching cinema's "limited path problem"	Dynamic choice systems (e.g., 40,000+ choice combinations in Detroit: Become Human) enabling open chaos while preserving thematic order
"Excessive dominance/absence" of authorial intent	"Synergetic balance": user participation in meaning co-creation (injecting negative entropy) while "order parameters" (themes) prevent the dissolution of authorial intent.

This evolution demonstrates that interactive images represent not mere "technical upgrades" but theoretical realization of nonlinear narrative—transforming chaos, fractals, and synergetics into perceptible user experiences, marking the first time narrative art fully aligns with scientific understanding of complexity.

3.5 Cross-Case Comparison and Theoretical Validation

To systematically clarify the evolutionary logic of nonlinear narrative carriers, this section constructs a comparative framework along three dimensions: "theoretical fit," "depth of interaction," and "narrative effect."—verifying how each generation progressively aligned with nonlinear scientific principles.

Dimension	HypertextLiterature (Afternoon)	BranchingCinema (RunLolaRun)	ContemporaryInteractiveImages (Detroit:BecomeHuman)
Theoretical fit	Partial (fractals/chaos)	Partial (chaos/catastrophes)	Comprehensive (fractals/chaos/dissipative structures/synergetics)
Nature of User Input	Passive selection (fixed links)	No input (pre-edited paths)	Active co-creation (dynamic choice-feedback loops)
Narrative Order Maintenance	Unstable (entropy-dominated)	Rigid (director-controlled order)	Balanced (attractor-guided dynamic order)
Meaning Generation Model	Author-centered (reader decoding)	Director-centered (viewer reception)	Collaborative (user-director-system co-creation)

This comparison confirms two core evolutionary trends: First, application of nonlinear theories expanded from "single theory attempts" to "multi-theory integration," reflecting deeper understanding of complexity. Second, user agency evolved from "marginal participation" to "core co-creation," fulfilling Prigogine's vision that "open systems depend on external energy exchange"—users transformed from passive narrative recipients to active "negative entropy injectors."

3.6 Technological Empowerment: Material Foundations for Theoretical Implementation

The maturity of interactive images relies on three key technological breakthroughs that translate abstract nonlinear scientific principles into perceptible narrative experiences:

3.6.1 Dynamic Choice-Feedback Systems

Unlike hypertext's static link libraries, modern interactive cinema builds "choice-to-narrative response" loops through real-time data processing. Detroit: Become Human, for instance, employs a branching-logic engine that tracks more than 40 000 choice permutations, dynamically recalibrating character relationships (e.g., Markus's prestige value with humans) and plot modules (the "android alliance" arc is unlocked only when Connor's deviancy index crosses preset thresholds).This engine embodies Haken's "synergetic subordination principle": user choices (fast variables) continuously alter subsystem states, while the core theme of "what it means to be human" (slow variable/order parameter) guides the system toward macro order—avoiding hypertext's entropy increase while breaking through the rigidity of branching cinema.

3.6.2 Thematic Attractor Visualization

To resolve hypertext's "disorientation dilemma," interactive images visualize "strange attractors" through UI/UX design. Black Mirror: Bandersnatch's post-multiple-playthrough "narrative map" shows all branch paths ultimately converging on 5 core endings, each labeled with thematic tags (e.g.,"illusion of free will,""creative destruction"). This design translates Lorenz's abstract"topological space constraints" into intuitive guidance: users perceive choice freedom while visually identifying thematic boundaries. Similarly, The Witcher 3: Wild Hunt's "quest log" highlights connections between side quests (micro fractals) and main plot (macro attractors), resolving fractal theory's"scale confusion" in hypertext.

3.6.3 Community-Driven Meaning Cycles

Contemporary interactive images extend dissipative structure's "external energy exchange" from individual users to collective communities. Reddit's Detroit: Become Human forums and Steam's "choice analysis posts" form "narrative meaning ecosystems": users share "hidden choices" (e.g.,

Kara's "underground railroad" path), debate thematic interpretations (e.g., "whether androids truly possess sentience"), and even create fan mods to expand plot modules (e.g., adding a "fourth android protagonist"). This collective participation injects continuous negative entropy into narrative systems—unlike hypertext's "isolated reading experiences," meaning generation here doesn't terminate with reader exit. As Prigogine emphasized, "the vitality of open systems lies in continuous interaction with the external environment"; community participation transforms interactive narrative into self-renewing complex systems rather than static works.

3.7 Limitations and Theoretical Reflections on Contemporary Interactive Images

Despite being the current pinnacle of nonlinear narrative, interactive images still face tensions between scientific logic and artistic expression:

3.7.1 "Complexity Paradox" in Choice Design

To embody chaos theory's "butterfly effect," developers often pursue numerous choices (e.g., 40,000+ combinations in Detroit: Become Human), but excessive complexity causes "choice fatigue"— some of players reported "skipping dialogue to rush through choices" . This exposes a core contradiction: nonlinear science requires "sufficient complexity for order emergence," while artistic experience demands "manageable complexity for immersion." A potential solution lies in "adaptive complexity": using AI to adjust choice quantity based on user behavior(e.g., trimming trivial choices for plot-fluent, focus-oriented players), balancing scientific authenticity with artistic accessibility.

3.7.2 Risk of "Excessive Thematic Constraints"

To avoid entropy increase, interactive cinema relies on "strange attractors" (themes) to constrain choices, yet excessive constraint reduces user agency to an illusion. In Black Mirror: Bandersnatch, for instance, the option to "rebel against the director" ultimately loops back to the leitmotif of "the illusion of free will"—leaving some viewers feeling "manipulated". This suggests redefining attractors as "guiding frameworks" rather than "rigid cages." Future designs could employ "fuzzy attractors"—themes with flexible boundaries (e.g., Stardew Valley's "community building" theme allowing both "collaborative farming" and "hermit lifestyle" paths), respecting chaos theory's "bounded randomness" while preserving user autonomy.

3.8 Case Evolution Conclusion

The evolutionary trajectory of nonlinear narrative carriers—from hypertext's "theoretical exploration"through branching cinema's"structural simplification"to interactive images"theoretical integration"—It essentially reflects the gradual alignment between narrative logic and the cognition of scientific complexity. Each generation addressed predecessors' dilemmas through technological progress and theoretical deepening:

- Hypertext demonstrated nonlinear structure feasibility but failed at order maintenance (lacking dissipative structures);
- Branching cinema resolved disorientation but sacrificed user agency (synergetic imbalance);
- Interactive images integrated all nonlinear theories, achieving "order within chaos, constraints within openness, collaboration within agency" through technology—realizing true harmony between narrative art and complex systems science.

This evolution represents not merely a formal narrative shift, but a cognitive revolution: as humanity's understanding shifted from linear simplicity to nonlinear complexity, narrative—once a tool for "simplifying reality"—has become a medium for "simulating complexity," profoundly reflecting science and art's interactive role in shaping human cognition.

4. Discussion: The Paradox of Freedom and Control

The evolution of nonlinear narrative carriers (from hypertext to interactive images) reflects not only technological progress but also ongoing reconciliation of four core philosophical tensions. These paradoxes originate from nonlinear scientific theories analyzed earlier; they represent not flaws to eliminate but core sources of narrative art's cognitive value. This section dismantles each paradox, combining theoretical roots and case evidence to illustrate how interactive images advance the dialogue between freedom and control.

4.1 The Paradox of Autonomy and Connectivity

Soliton theory defines "stable individuals"—units maintaining integrity while interacting with macro systems. This concept directly maps nonlinear narrative's core challenge: How to preserve narrative unit (or user choice) autonomy without causing overall fragmentation?

Hypertext literature (e.g., Afternoon) failed this paradox: each text node ("narrative soliton") possessed excessive autonomy—readers could jump between unrelated memory fragments without intentionally designed connectivity, ultimately causing "meaning entropy increase" (Joyce, 1995). Branching cinema (e.g., Run Lola Run) swung to the opposite extreme: timeline solitons (three loops) remained strictly controlled by directors, sacrificing autonomy for connectivity—each loop followed the "20-minute rescue" structure with no user-driven variation space.

Interactive images resolved this paradox by redefining relationships between soliton autonomy and system connectivity. In Detroit: Become Human, each android protagonist functions as a"narrative soliton": detective Connor, caretaker Kara, and revolutionary Markus maintain independent character arcs (autonomy)—users can choose Connor's "disobedience" or Kara's "abandonment of Alice." Yet these solitons achieve dynamic connectivity through "relationship feedback systems": if Markus leads violent protests (autonomous choice), Connor's "deviancy index" rises (connective effect), increasing likelihood of subsequent android revolution alliance. This design embodies soliton theory's core insight: stability doesn't require isolation. Just as Russell's "solitary waves" maintain form while moving through water, interactive narrative units' autonomy derives from (rather than contradicts) macro system connections.

The paradox's solution lies in "intentional connectivity": interactive images avoid forcing trade-offs between autonomy and connectivity, instead designing rules for mutual reinforcement. This prevents hypertext's fragmentation while breaking branching cinema's rigidity, constructing narratives where "choices possess both meaning (autonomy) and impact (connectivity)."

4.2 The Paradox of Chaos and Order

Chaos theory's "strange attractors"—mechanisms confining chaotic trajectories within meaningful limits—reveal nonlinear narrative's core dilemma: absolute randomness reduces narrative to meaninglessness, while absolute order diminishes it to passive spectacle.

Hypertext literature favored chaos over order: Afternoon's 900+ links generated nearly infinite reading paths (chaos), but without thematic attractors, some of readers "abandoned due to confusion". Branching cinema prioritized order over chaos: Sliding Doors' two timelines remained pre-edited by directors (order), lacking user-driven chaos that reduced choices to illusion—viewers merely watched parallel stories rather than shaping them.

Interactive images balanced this paradox through"bounded chaos"—aligning with Lorenz's"strange attractor" logic. In The Witcher 3: Wild Hunt, players enjoy extensive chaotic freedom: ignoring main quests to hunt monsters, develop relationships, or destabilize kingdoms. Yet all choices remain implicitly guided by two thematic attractors: "Geralt's honor code" and "Ciri's fate." For example, choosing to kill innocent villagers (chaos) prompts cynical Geralt dialogue (attractor feedback), potentially causing Ciri to reject his guidance—pulling chaotic paths back to the"moral consequence" thematic framework.

Black Mirror: Bandersnatch further developed "fuzzy attractors": the core theme "illusion of free will" functions not as rigid cage but flexible framework. When viewers choose Stefan's "game disc destruction" (seemingly rebellious chaotic act), the narrative responds that "destruction remains part of free will's illusion"—attractors balance by adapting to rather than suppressing chaos. This solves the paradox: order in nonlinear narrative serves not as freedom's obstacle but precondition for meaningful freedom. As chaos theory shows, most vibrant systems thrive not in unconstrained environments but through "coexisting constraints and freedoms."

4.3 The Paradox of Openness and Boundaries

Dissipative-structure theory holds that open systems sustain vitality by exchanging energy with their environment—posing a critical narrative question: how can user or community input be admitted without the text devolving into a meaningless collection of concepts?

Hypertext fiction's openness lacked such boundaries: Afternoon offered no narrative limits, letting readers interpret the "son's death" as literal fact, metaphor, or irrelevant digression, dissipating meaning altogether.—yet this caused "meaning fragmentation" preventing shared interpretation (Hayles, 2002). Traditional linear films suffered excessive closure: directors pre-fixed meanings (e.g., "redemption" in Schindler's List), rejecting user input—violating dissipative structures' "requirement for external energy exchange."

Interactive images resolved this through "intentional boundaries": opening to user input while anchoring to core themes to prevent meaning collapse. In Stardew Valley, games fully open user choices: farming, mining, relationships, or ignoring "community center" quests. Yet "community building" boundaries persist—even solitary players must interact with villagers (e.g., buying seeds from Pierre's store), and collaborative actions (e.g., restoring the community center) receive narrative depth rewards. This "limited openness" fulfills Prigogine's dissipative structure vision: systems need external energy (user choices) for dynamism, while boundaries (themes) prevent disorder.

Community-driven meaning cycles further optimized this balance. In Elden Ring, developer FromSoftware established "reunite the Elden Ring" boundaries while opening "Golden Order" interpretation to players. Reddit communities debate "Golden Order's morality," with fan mods expanding narratives to explore unanswered questions (e.g., "outer god origins"). This forms "dissipative ecosystems": developer boundaries provide stability, while community input injects negative entropy—avoiding hypertext's meaninglessness and linear narrative's stagnation.

4.4 Power Reconfiguration: Author, Text, and Reader

These three paradoxes ultimately point to deeper transformation: nonlinear narrative subverted traditional "author-controlled, reader-consuming" power relations. This reconfiguration isn't simply "power transfer from authors to readers" but science-based "system interaction" reallocation.

• Linear Narrative/Branching Cinema: Author Dominance. In Run Lola Run, director Tom Tykwer retained full control—defining timelines, endings, and "chance vs. fate" themes. Readers/viewers remained passive recipients, solely absorbing authorial messages. This aligns with linear science's "deterministic worldview": systems (narratives) controlled by single external forces (authors).

• Hypertext Literature: Imbalanced Reader Empowerment. Afternoon transferred power to readers—choosing paths and co-creating meaning. Yet this empowerment lacked regulation: without authorial boundaries, readers often felt "disoriented" (Joyce, 1995), diluting texts' original intentions (e.g., Joyce's memory exploration). This resembles early nonlinear science's focus on "structureless chaos": unregulated freedom causes disorientation.

• Interactive Images: Collaborative Power. Interactive images established balanced tripartite power

among authors, texts, and readers—aligning with Haken's synergetic "subordination principle." Authors (e.g., Detroit: Become Human's Quantic Dream) set "order parameters" ("sentience" and "justice" themes) and design text dynamic rules (e.g., "branching logic engines"); texts mediate by processing reader choices and feeding back their consequences (e.g., "Connor's deviancy index rise"); readers provide "fast variables" (choices) shaping narrative details without exceeding authorial thematic frameworks.

This balance appears clearly in Black Mirror: Bandersnatch: Netflix (author) defines "free will illusion" themes, viewers choose Stefan's actions, and texts redirect choices potentially deviating from themes through loops. Even fan communities expanding narratives (e.g., creating "unofficial endings") operate within authorial boundaries—never rewriting the core premise of "game developer's choice dilemma."

Thus, the reconfiguration of power essentially shifts from "top-down control" to "system collaboration"—consistent with nonlinear science's understanding of complex systems: order emerges not from single controllers but subsystem interactions (authors, texts, readers).

5. Conclusion: Narrating a Nonlinear World

This research traces nonlinear narrative's evolution from hypertext literature to contemporary interactive images, revealing a core truth: narrative transformation represents not random aesthetic experimentation but profound self-renewal as narrative art responds to nonlinear science's revelation of "world complexity." For two millennia, Aristotle's mimesis anchored narrative in linear causality—reflecting humanity's early attempts to simplify reality through "beginning-development-ending" structures. However, 20th-century nonlinear science (chaos, fractals, dissipative structures) shattered this cognitive framework, proving reality's dynamic, interconnected, and emergent nature. As humanity's cognitive mirror, narrative necessarily evolved: from hypertext's initial branch structure explorations through branching cinema's controlled multipath attempts, each generation struggled to translate scientific logic into artistic expression—until interactive images achieved maturity.

As the current core carrier of nonlinear narrative , interactive images realize unprecedented alignment between nonlinear scientific philosophy and narrative aesthetics through technological innovation. They balance narrative unit autonomy and connectivity via dynamic feedback systems (soliton theory), reconcile chaotic choices with ordered meaning through "fuzzy thematic attractors" (chaos theory), prevent meaning collapse amid openness using "intentional boundaries" (dissipative structure theory), and establish tripartite power balance among authors, texts, and readers for collaborative meaning generation (synergetics). Works like Detroit: Become Human and Black Mirror: Bandersnatch demonstrate how technology—from real-time branching logic engines to community-driven meaning cycles—functions not merely as "support tools" but as"translators"converting abstract scientific principles (e.g., "negative entropy exchange,""strange attractor constraints") into immersive, perceptible user experiences. In this sense, interactive images represent not just nonlinear narrative's "pinnacle" But milestones where narrative art finally catches up to the scientific understanding of reality.

Future frontiers of nonlinear narrative will be shaped by generative AI and emerging technologies, propelling narrative systems toward more dynamic, intelligent "living dissipative structures."Unlike current interactive images (with developer-preset plot branches), generative AI could enable "real-time narrative emergence": for example, AI-driven interactive games analyzing player behavior (e.g., consistent empathy toward marginalized groups) to dynamically generate plot units maintaining fractal self-similarity (mirroring "justice" macro themes) while preserving soliton autonomy (aligning with player choices). This would transform narrative from "predefined systems" into "self-evolving ecosystems": AI serving as "dynamic order parameters" adjusting thematic constraints based on user input (negative entropy); users evolving from"choosers"

to "narrative rule co-creators"—dissolving traditional boundaries between "creators" and "experiencers."

This future extends rather than abandons this research's explored nonlinear scientific logic. Nonlinear science teaches that complex system vitality arises from interactions between freedom and control, openness and boundaries—Just as narrative—humanity's tool for making sense of the world—continues to evolve alongside our deepening understanding of complexity. From hypertext's static links to future AI-generated narratives, nonlinear narrative's core pursuit remains constant: narrativizing nonlinear worlds into "meaningful interactive wholes" rather than "chaotic fragments"—reflecting both scientific truth of reality and artistic richness of human experience.

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