N. Katherine Hayles, *The Cosmic Web* and the problem of articulation

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Abstract

Operating at the intersections of literature, science and technology, N. Katherine Hayles is a preeminent thinker whose interdisciplinary work has come to be highly influential across a range of fields. This article focuses upon Hayles' first book, *The Cosmic Web*, published in 1984. Exploring the conditions of its production and reception, it shows how this relatively neglected book, in terms of citations and attention, established a series of influential ideas that have since become core within the critical study of data, algorithms and artificial intelligence. This particular article seeks to understand that original text along with the ideas and approaches that it established. The article suggests that, drawing on Hayles' own conceptual framing, *The Cosmic Web* is part of the 'cultural matrix' through which critical studies of data, algorithms and AI continue to emerge. The article focuses directly on the methods deployed by Hayles, and reflects on how literary sources were used to provoke the analytical imagination. Within this, it examines Hayles' use of literary sources to explore broader social and cultural forces. The article asks how Hayles used that method to develop the metaphor of the cosmic web and its connotations of interconnection and stickiness. It focuses on *the problem of articulation* identified by Hayles and the methodological and conceptual possibilities *The Cosmic Web* still offers for seeking to address it today.

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In 1984 N. Katherine Hayles, a visiting associate in English at the University of Missouri-Rolla, published *The Cosmic Web: Scientific Field Models & Literary Strategies in the 20th Century* with Cornell University Press. It was the author's first book, to be followed by a number of highly successful volumes in the decades that followed. Despite Hayles' later works achieving wide recognition and citation, *The Cosmic Web* has remained relatively neglected in terms of attention and discussion. A search on Scopus indicates that it has received 45 citations, Web of Science reports 122 and Google Scholar 558. Yet the comparatively limited engagement with the book belies its importance, both for the author's own work and for the wider field it would come to indirectly shape. This is not simply to suggest that *The Cosmic Web* is a lost classic, though I think it should be allocated that status, nor is it to say that it should have garnered much more interest, it is instead to argue that this particular book is situated at an understated yet influential position within the development of a range of debates that have emerged since.

Even though it is not necessarily directly cited itself, it has been especially important in establishing ideas that have since taken form under labels such as critical data studies, critical studies of algorithms and critical studies of artificial intelligence. To use Hayles' (1984: 26) own concept for dealing with the reach of ideas, *The Cosmic Web* was a crucial part of the 'cultural matrix' within which these fields propagated.

In the time since the publication of *The Cosmic Web*, N. Katherine Hayles has become a highly influential figure operating at the intersection between science, technology and literature. Hayles continues to set the agenda for work around emergent forms of intelligence, cognition and mediated ways of thinking (as described by Amoore, 2019a). In this article, over fourty years after its publication, I seek to revisit Hayles' first book, tell something of its context and reception, and unpick aspects of its argument and approach that remain significant today. In particular, this article identifies how the 'cosmic web' as a metaphor enables the conceptual development of crucial ideas around *interconnectedness* and *stickiness*. From this, the article looks at how the properties of these two concepts from Hayles' opening volume pose ongoing methodological questions concerning what might be thought of as *the problem of articulation*. This is a problem that persists in the analysis of digital societies.

In an exploration of the influence of Hayles' work, Louise Amoore observes how 'at this contemporary moment, when it might appear that science and literature, and humans and machines, are coevolving in novel and often troubling ways, the work of N. Katherine Hayles stands as compelling testament that these histories have never been separable' (Amoore, 2019b: 5). The moment mentioned by Amoore refers to a particular escalation of embodied technological transformations, and to the presence of algorithms in particular. In conceptual and methodological terms, Hayles interest in these lines between humans and machines or between science and literature, was, at least partially, set in motion by *The Cosmic Web*. Its influence, then, is significant beyond the immediate or direct impact that it had in its own right. *The Cosmic Web* provides insights into the trajectory of Hayles' own thinking, whilst also representing a rupture or intervention that has indirectly shaped understandings of embodiment under the conditions of an advancing 'regime of computation' (Hayles, 2005: 17). For these reasons, it is worth understanding the book's production, its reception and, most crucially, the thinking, ideas and conceptual formations within it.

The limits of thought

Having created a space for thinking across limits, Hayles' work is not readily categorised using established academic schema. The breaching of the boundaries that demarcate disciplines, the cracking of 'fractal distinctions' (Abbott, 2001: 13-14), is a defining property of Hayles' approach. Tracking ideas across such boundaries was an objective from the outset. Back in 1989, in the introduction to an interview with Hayles conducted for the *Iowa Journal of Literary History*, published after *The Cosmic Web* and shortly before the publication of Hayles' second book, Suzanne Araas-Vesely (1989: 1) captured the depth of this interdisciplinarity, writing that:

> 'Katherine Hayles has unusual credentials for a literary scholar and critic. She has a master's degree in Chemistry from the California Institute of Technology (1969). She has

> taught literature at Dartmouth College, the California Institute of Technology, and the University of Missouri-Rolla. In 1985 she came to the University of Iowa, where she has been awarded a faculty scholarship, 1986-89. She has made presentations at numerous conferences, has written articles on subjects ranging from Renaissance drama to modern fiction, and is the author of one book, *The Cosmic Web: Scientific Field Models and Literary Strategies in the Twentieth Century*, and two forthcoming studies, including *Chaos Bound: Orderly Disorder in Contemporary Literature and Science*, due out the first of next year. In 1991 she will take over the presidency of the Society for Literature and Science.'

The credentials for working across boundaries were established early. In the preface to *The Cosmic Web* itself, Hayles (1984: 11) also expresses gratitude to Dartmouth College for a 'Faculty Fellowship in the fall of 1979, during which a start was made on this book, and to the National Endowment for the Humanities for a fellowship during 1979-1980, which allowed me to complete the original draft'. The NEH fellowship was hosted at the California Institute of Technology. Hayles (1984: 11) goes on to mention that revisions to the book were completed in the Summer of 1983 at the University of Missouri-Rolla, whilst on a Weldon Spring Faculty Grant. It is also worth noting that the Society for Literature and Science (which is now called the Society for Literature, Science and the Arts) mentioned above was inaugurated in 1985, with Hayles becoming it's fourth president in 1991, illustrating the presence of a critical mass of researchers working across similar disciplinary boundaries in that period (SLSA, n.d.).

Going back earlier, the exploration of ideas beyond disciplinary limits of thought was a recurring theme of the work that led up to *The Cosmic Web*. Hayles made the switch from completing a postgraduate degree in Chemistry in 1969, going on to complete a Masters and PhD in English Literature in 1970 and 1977 respectively. The science and literature interface was present within Hayles' training and experience. The early interest in blending and breaking disciplinary boundaries is also made clear on Hayles own CV, where the first two roles listed under the heading 'professional experience' are 'Research Chemist, Xerox Corporation' in 1966 and 'Chemical Research Consultant, Beckman Instrument Company' from 1968 to 1970. These two roles were followed, in the mid-to-late 1970s, by roles teaching English at Dartmouth and the California Institute of Technology (see Hayles, n.d.). Hayles was working across science and literature from these early career stages.

In the passage that opened the preface to *Chaos Bound*, the book that followed *The Cosmic Web*, Hayles reflected back on the interests driving the first book, which had then continued to inspire its follow-up:

> 'Some years ago I began to wonder why different disciplines, sufficiently distant from one another so that direct influence seems unlikely, should nevertheless focus on similar kinds of problems about the same time and base their formulations on isomorphic assumptions. It seemed to me then, and still does seem, that the most plausible explanation is cultural. Different disciplines are drawn to similar problems because the concerns underlying them are highly charged within a prevailing cultural context. Moreover, different disciplines base the theories they construct on similar presuppositions because these are the assumptions that guide the constitution of

> knowledge in a given episteme. This position implies, of course, that scientific theories and models are culturally conditioned, partaking of and rooted in assumptions that can be found at multiple sites throughout the culture' (Hayles, 1990: xi).

This represents a pursuit of an attunement to the ideas and problems that run across disciplines and an interest in how these can be questioned and understood. There was a crucial addendum to the overarching observations, in that despite the shared cultural conditions 'different disciplinary traditions can impute strikingly different values' (Hayles, 1990 xiv). The cultural matrix is not expected to dictate or produce unified values.

This attentiveness to the cultural context of disciplinary knowledge shows up in other reflections from the time. Asked about her field of study during the 1989 interview for the *Iowa Journal of Literary History*, Hayles responded by questioning the idea of the work being located in a single field:

> 'The first thing I notice about this question is that it's phrased in the singular. *The Cosmic Web* was not so much about a single field, as about a field as an interactive relationship between subject and object. There are, for example, any number of physical fields one could talk about—the dynamic field, quantum mechanical field, and so forth— but the field as a concept has as its core the denial of the strict separation of subject and object. It's in this sense that it's important to range literature and language alongside field theories, because literature and language are central to the relationship between subject and object.' (Hayles in Araas-Vesely, 1989: 1)

This illustrates an interest in unsettling such boundaries to thought and working beyond a single field. Hayles turns the question back to the analysis of *field* itself, which is a core focus of the book too. In the pages of *The Cosmic Web*, in discussing D H Lawrence more specifically, it is claimed that in certain readings the model 'blurs the boundaries between subject and object' (Hayles, 1984: 110). One result of this, which Hayles (1984: 136) suggested was missed by Nabokov, is that the 'desire to control is predicated on the assumption that it is possible to make an unambiguous separation between the one who controls and that which is controlled'. Even the desire to control, as well as control itself, fall, as we will see, into the problem of articulation.

During the reflections provoked by being asked about the field in which the work was situated, Hayles proceeded by making the closeness of the interviewer's question to *The Cosmic Web*'s argument more explicit:

> 'You're touching here on an aspect of my first book that I try to go beyond. In *The Cosmic Web* I hypothesized a cultural matrix without really looking at what it meant or how it works. In my second book, *Chaos Bound*, I've tried to go more deeply into the questions and, at the same time, to pose a more complex model for how interactions between disciplinary inquiries and cultural institutions take place. You're quite right to suggest that it's too simple to think of one cultural matrix in an age, because clearly culture is highly fissured and stratified, not by any means homogeneous or monolithic.' (Hayles in Araas-Vesely, 1989: 5)

Illustrating its ongoing momentum, Hayles was already seeking to work beyond and extend the arguments of The *Cosmic Web*. The interview deals here with the concept of the 'cultural matrix', in this case using it to think about disciplinary fields. This answer also hints at the

‘fissured’ formations of culture, and that the ‘cultural matrix’ should not be reduced to a single unified feature of a particular age.

Although I’ve spoken of it as being relatively neglected, compared to most books *The Cosmic Web* was actually quite widely reviewed at the time of its publication. I located nine reviews that appeared in academic journals. The reviewers included Howard Eiland (1985), who, showing an interest in Hayles’ approach to the indeterminacy and limits of fields, would go on to play a major role in editing and translating Walter Benjamin’s writings (see for example, Benjamin, 1999; and the Harvard University Press’ multi-volume selected writings of Benjamin’s works) as well as co-authoring a major biography on the figure (Eiland & Jennings, 2014). It is notable that the nine reviews were all published in literary and language journals, which is suggestive of where *The Cosmic Web* was thought to belong as a text, perhaps because of its source material and the authors that Hayles was dealing with in its chapters. Yet the permutations of the text would spread far beyond that initial home. Khachig Tölölyan, who later, in 1991, established the journal *Diaspora: A Journal of Transnational Studies* as its founding editor (as described in Tölölyan, 1991), opened a review of the book with the line: ‘A professor of literature who studied chemistry for a number of years, Hayles orchestrates the two cultures with few jarring notes’ (Tölölyan, 1985: 1174).This unusual interdisciplinary property of both Hayles’ approach and *The Cosmic Web* itself, was a theme in many of the reviews from the time.

The frequent allusions to this cross-boundary mode of working suggests that it was an aspect of the work that stood-out to the reviewers. Background and training are often evoked in these credentials, with it pointed out that Hayles is ‘a trained chemist and literary critic’ (Rousseau, 1988: 322) or that the author is ‘a scientist as well as a literary scholar’ (Peterfreund, 1986: 156) and, elsewhere, that ‘Hayles has unique qualifications: presently an assistant professor of English, she has advanced degrees in science and in literature as well as experience as a research chemist’ (Lee, 1986: 103). It is not just the rareness of such an approach that attracts comment in the reviews, it is also the depth with which this one book manages to deal with wide-ranging and very different forms of knowledge. One review surmises that ‘N. Katherine Hayles, a chemist who now teaches English at the University of Missouri-Rolla, can decipher both kinds of texts deftly, and her book *The Cosmic Web* is one of the finest examples of the method to date’ (Slade, 1987: 81). In another response, it is considered notable that the scientific ‘field concept provides a useful frame for examining modern literature’ (Elkin, 1986: 211). Another reviewer concludes that Hayles:

> ‘accomplished her purpose of blazing many trails and opening dialogue between the Two Cultures. Scientists and non-scientists are caught in the same spinning web and are trying to talk about it - to themselves and now to each other.’ (Lee, 1986: 104).

Speaking across traditions, it was claimed that ‘Hayles does demonstrate a sure ability to make the nuances of post-Newtonian mathematics and physics available to humanists’ (Peterfreund, 1986: 159). For Rousseau ‘Hayles's approach is especially welcome because she understands the physical science discussed…And her treatment entails neither polemical blasts nor rhetorical bombast: merely field concepts and their inevitable consequences’ (Rousseau, 1988: 323).

Elsewhere the scope of the coverage across disciplines is noted. Acknowledging the ambition in the text, Schachterle explains how:

> ‘Hayles examines in detail the implications for culture of the force-field model displacing the Newtonian absolutes of time, space, and particle. Conceptualizing physical reality as concentrations of energy in a field rather than material particles leads in Hayles's analysis to a firm grasp of why early twentieth-century science challenged subjective/objective dualisms. The characteristics which we observe in what we call space and time arise directly from the distribution of energy within a plenum; and we as observers are integral parts of that plenum. Self-referentiality enters physics as well as literature: in neither discipline is it possible any longer to conceptualize matter or text as occupying a privileged place independent of mind’ (Schachterle, 1987: 82)

The review attempts to grapple with the wider implications of *The Cosmic Web*, and in so doing points at the ongoing issues that the book was establishing. As well as concentrating on the ‘attempt to avoid such dualisms,’ Schachterle (1987: 82) concludes that Hayles ‘excels at close readings of complex texts, and is fully attentive to the implications for structure of her cosmic web idea’. As well as reading the literature closely and perceptively, Schachterle also found the analysis of the science convincing, noting how ‘Hayles skillfully rehearses the relevant concepts from science, from the now-twice-told tales of entropy and the physics of rocket flight through the more curious puzzles of singularities and black hole’ (Schachterle, 1987: 83). In Lee’s review some of the claims concerning the movement of ideas across literature and science are questioned, whilst the approach was considered of most value, arguing that ‘although she does not finally convince me that literature has much influence on science, her multidisciplinary approach is one to be emulated’ (Lee, 1986: 103). The concern about what might be missed by such a wide net is noted elsewhere with Tölölyan wondering if by ‘emphasizing what must of necessity remain unknown, Hayles allows too much of what is known about the production of knowledge to slip through her web’ (Tölölyan, 1985: 1174).

The book’s expansive approach to the boundaries of knowledge wasn’t universally popular, of course. In a review that followed in 1985, a year after the book’s publication, in the journal *MFS Modern Fiction Studies*, Don D. Elgin praised the opening sections of the book but indicated that it was ‘not as good as it might have been’, accusing Hayles of forgetting the audience, using ‘murky language’, and claiming that the book represented ‘an example of what happens when an author forgets her audience and becomes so entrapped in the dialectic of her method that she forgets the principal purpose of criticism: to explain in such a way as to make aesthetic judgments possible’ (Elgin, 1985: 853). It would seem though that despite acknowledging Hayles’ interdisciplinary background as being a positive aspect of the work, the book was still reviewed and evaluated by Elgin from a distinctly and restrictive disciplinary perspective. Whereas in *Modern Language Studies*, Schachterle reflected on how Hayles’ book was ‘especially rewarding in showing how conceptual mastery of contemporary physics can provide a metaphorical vocabulary that enriches our understanding of contemporary writing’ (Schachterle, 1987: 78). There are inevitable tensions where ideas are tracked across the limits of thought.

On the surface, *The Cosmic Web* may appear very different to Hayles' later works, both in terms of method and conceptual thematics. Yet, as I've suggested, the book was to be foundational for what would follow - setting in motion ideas and approaches that would be realised in significant and influential ways into the future. In this way, going back to *The Cosmic Web* creates two opportunities. First, it enables us to see the roots of the ideas that would later spread throughout contemporary studies of embodied technology, the computational challenge to knowledge, the category of the human, and the potential of cognitive systems to reshape agency (it should be noted that unconsciousness is dealt with directly as early as chapter 3 of *The Cosmic Web*). More importantly though, second, returning to *The Cosmic Web* allows us to unearth the ideas within it and to see the value that they have in their own right. Its insights are set within a particular historical framing, yet they no doubt have the scope to remain pertinent today, and may find new life in the contemporary setting beyond those originally intended by Hayles. I now turn to the pages of *The Cosmic Web* not to look if it succeeded in its aims, but to explore what those aims were, the methodological questions these aims continue to pose and the pertinent concepts that emerged from the pursuit of those aims.

The cosmic web as metaphor and method

In the preface to *The Cosmic Web* Hayles (1984: 9) identified the 'field concept' as being at the 'heart' of a 'revolution' of knowledge, with the book attempting to examine its 'various manifestations in the models of physics and mathematics, the theories of the philosophy of science and linguistics, and the structure and strategies of literary texts'. The field concept is a framing device used by Hayles to enable an exploration of the presence of certain qualities across different types of knowledge. It became a means for thinking across these developments so as to draw-out similarities in seemingly quite different and disperate bodies of knowledge. Indeed, Hayles clarified that the 'field concept…is not identical with any single field formulation in science,' instead, it is argued, the term 'draws from many different models those features that are isomorphic' (Hayles, 1984: 9). We could draw the conclusion that it is what the term can do rather than what the term *is* that matters in this approach. The aim of the book, which has this type of ongoing project as its tone, was 'studying some of the embodiments of the field concept' (Hayles, 1984: 10). It seeks out permutations of ideas. A core argument was that 'developments in a number of different disciplines can be related to the emergence of modern field models' (Hayles, 1984: 22). The literature and science crossover is where Hayles operates, with the focus set toward the literature in order to see the connections of the 'cultural matrix'. The possibility was to take the current 'position' and then 'to develop further the parallels between modern literature and modern science' (Hayles, 1984: 41). The aim was finding how 'the connecting link between these ideas is the field concept,' in order to then 'demonstrate that it is as capable of informing literary strategies as it is of forming scientific models' (Hayles, 1984: 25). This is to claim a permeability running in different directions.

Hayles was not suggesting that this was necessarily a deliberate or even conscious moving of models or ideas between forms of knowledge. Hayles used Saussure as an example to emphasise this point, suggesting that because:

> ‘Saussure’s proposals are remarkably similar in spirit to those occurring about the same time in physics and mathematics does not require that Saussure knew of Einstein’s 1905 papers or read Principia Mathematica. Indeed, to suppose that such parallels require direct lines of influence is to be wedded to the very notions of causality that a field model renders obsolete.’ (Hayles, 1984: 22)

This specific example was used to make a point about the way ideas can spread, which in turn then was also used to make a point about the move away from causality as an explanation. For instance, Hayles said that Lawrence and Nabokov were chosen for inclusion because they ‘demonstrate how writers who are relatively ignorant of the new science nevertheless participate in the cultural matrix and so, willy-nilly, encounter in some form the matrix’s underlying paradigm’ (Hayles, 1984: 26). The problem would be that ‘the cultural matrix guides individual inquiry at the same time that the inquiry helps to form, or transform, the matrix.’ (Hayles, 1984: 23). It is this idea of the cultural matrix that enabled Hayles to make the case for a non-causal influence of the model.

As this might suggest, the tone of the opening sections of *The Cosmic Web* are sweeping in their style, as they seek out linkages across vast literatures. For instance, in framing the book it was argued that:

> ‘The Twentieth Century has seen a profound transformation in the ground of its thought, a change catalyzed and validated by relativity theory, quantum mechanics, and particle physics. But the shift in perspective is by no means confined to physics; analogous developments have occurred in a number of disciplines, among them philosophy, linguistics, mathematics, and literature.’ (Hayles, 1984: 15)

The shifting modes of reason offer a background to the other claims made in the book. Hayles suggests that there are comparable shifts occurring across disciplines throughout the sciences and humanities. These analogous developments are not immediately obvious as, according to Hayles (1984: 15), even ‘the people most responsible for the transformation did not necessarily consider themselves part of a larger movement; nevertheless, their streams of inquiry flowed in a similar direction, the converging courses of which changed the intellectual terrain of modern thought’. The scale of Hayles’ argument is made clear in this framing.

The convergences pushing at ‘modern thought’ were leading in a similar direction, even if the protagonists didn’t appreciate it. Hayles (1984: 15) observed that this movement’s ‘distinguishing characteristics, then, are its fluid, dynamic nature, the inclusion of the observer, the absence of detachable parts, and the mutuality of component interactions.’ (1984: 15). On the question of why this stream of thought was largely unacknowledged, Hayles (1984: 15) reasoned that this was because the ‘essence of the change is implicit in the heuristic models adopted to explain it’. It was an implicit type of reasoning within the frameworks of sense-making. For instance, in the chapter on Pirsig, Hayles looks at the pursuit of a ‘rhetoric’ able to deal with the ‘conflicting premises’ of a ‘fluid, dynamic reality’ that ‘eludes’ description on the one hand, and the ‘ultimate reality’ on the other (Hayles, 1984: 63). The ‘discontinuity’ (Hayles, 1984: 153) of narrative sequences, or stories, that might form reality, in this sense, are considered ‘indeterminate’ (Hayles, 1984: 145). When reading Borges, Hayles (1984: 165)

looked instead at the problem of articulating a conception of time as taking form in the 'destruction and reconstitution of series'.

The scale of the issues and expansive movement of the sentiment being tracked created a methodological dilemma for Hayles - the 'problem space' (Lury, 2020), was, in this sense, vast. Given its breadth, Hayles' method adapts to the wide range of possibilities so as to try to encompass what the field concept reveals. In keeping with this breadth Hayles (1984) argued that 'the only way to approach a satisfactory understanding of the field concept is to examine and compare a wide range of phenomena that embody it'. This, Hayles (1984: 9) reflected, is the 'major burden of this book'. It is quite a burden, given that this is a single text, which again brings the potential that the ideas will not be restricted only to its pages and are likely to continue beyond. Hayles (1984: 24) worked from the premise that 'well-known developments in the modern novel are part of a larger paradigm shift within the culture to the field concept'. Yet, in terms of method, scale was always going to be the problem, and so Hayles aimed to contain the project, clarifying that 'rather than attempt this history, I have assumed it by locating a group of representative novels within a larger cultural context that includes physics, mathematics, and philosophy' (Hayles, 1984: 24). Hayles' method was not to account for the full history but to identify representative instances within that wider picture in order to flesh out its features. This close-reading of a selection of targeted literary texts to explore wider concerns and to flesh out currents is an approach and method that Hayles has utilised in later works, and has become something of a distinctive methodological feature of Hayles' interdisciplinary writings (see for example Hayles, 2005).

In *The Cosmic Web* the selection of authors was particularly tricky, given that they are necessarily quite distant from any direct connection to the models Hayles was exploring. On the selection of literary sources Hayles explained that:

> 'Most of the authors I am concerned with know little of science, and what little they do know is often colored by their idiosyncratic interpretations. In addition, most of them write for a small literary audience, and this further helps to insulate them from developments in science. With a few exceptions, these authors are reacting not to science as such, but to a more general set of ideas pervasive in the culture.' (Hayles, 1984: 24-5)

The authors chosen are not writing about science, which is part of why they were selected. It allowed the core argument to be explored, specifically because these authors weren't directly dealing with the currents Hayles was identifying. By being distant from it, these authors provided evidence of its wider presence. Adding to this methodological insight, Hayles also provided further explanation about the selection of texts, pointing out that the:

> 'selection was guided by two criteria: first, I wanted texts that would reveal how wide the range is of literary strategies that can emerge from an author's encounter with the field concept; and second, I wanted texts that would evidence varying degrees of knowledge and sympathy toward science.' (Hayles, 1984: 25)

It is the exploration of a wide range of literary strategies that informed the sampling of texts for analysis. Clearly the selection of texts was important, given that the sampling is likely to be so central to the arguments, especially as only a handful of authors were to be included. Yet, Hayles' point was that these models would be found across texts, and so finding it in these

particular literary sources would act to be representative. It was explained that 'the desire to show the full complexity and range of response…also dictated the book's organization, for the literary chapters are arranged according to the authors' increasing resistance to the field concept.' (Hayles, 1984: 25).

Overall, the methodological choices are founded in an attempt to, as Hayles put it, select five literary texts that 'wrestle in some way with the implications of the field concept, from the first tentative imaginings of it in Lawrence to the exploration of the limits of imagining in Pynchon' (Hayles, 1984: 28). The focus of selection was the deployment of literary strategies relating to that concept, with the selection of authors intended to provide a 'rich diversity of strategies' (Hayles, 1984: 28). Hayles thought that 'for whatever stance these authors take toward the field concept, their encounter with it is affecting the shape of modern fiction' (Hayles, 1984: 28). Hayles' method is about a type of sampling of heuristics to facilitate the drawing of impressions of ideas. Pirsig is used to explore being *drawn* to the web, Lawrence for the topic of *evasion*, Nabokov for *ambivalence*, Borges for *subversion* and, finally, being *caught* in the web is explored through Pynchon. It is, Hayles argues late in the book, Pynchon who 'grasps the full implications of the field concept, including both its promise of a reality that is harmonious, dynamic whole and the problem it poses of how to represent that reality in the fragmented medium of language'. This is a crucial passage that encapsulates the tension that Hayles' book examines. There is a sense of a whole that is in tension with a defining and unresolved problem of articulating its actual dynamism. In Pynchon's text Hayles (1984: 169) identified a focus and anxiety for organizing 'diverse data into coherent patterns', an act that exposes the 'chaotic surface of the narrative the cognitive patterns that will let us classify and analyze' whilst also, at the same time drawing an awareness of the extent of 'the conscious effort that the reconstruction of pattern requires'. The point here, according to Hayles, is that Pynchon revealed a kind of 'double bind' in which:

> 'The perceived patterns imply that self-conscious cognition is skewing our society and driving us toward destruction; but in order to receive this message, we had to tame the unruliness of the text into cognitive patterns we understand, thus exercising over the text the same kind of control that created the problem in the first place.'

The act of sense-making is itself revealing for Hayles. The work of pattern recognition reveals through the labour required to find form and to articulate a sense of understanding against the unruliness.

It is here, in the burden of finding connections and relating embodied manifestations, that the central concept of the 'cosmic web' was introduced. Hayles explained that:

> 'the metaphor I have chosen to represent the world as construed by the field concept is the "cosmic web." That metaphor communicates something of the interconnectedness and "stickiness" of self-reference of which I have already spoken.' (Hayles, 1984: 10)

The cosmic web is used by Hayles as a metaphor for capturing and communicating the world as defined by the field concept. A web is both a set of connections and is sticky. The notion of the web performs this role, whilst the cosmic element brings in the ways of thinking. In short, the cosmic web captures the stickiness of the interconnections.

The problem of articulation

Inevitably questions about causality and description surface. Hayles was attempting to think about how influence worked across and flowed between forms of knowledge and narrative. Within this, Hayles (1984: 20) identified 'two restrictions to complete description'. The first was simply a question of scale and dynamism. We cannot produce a complete description:

> 'Because we cannot describe the totality of the dance, which is incessant and infinite, we must stop the kaleidoscope in our imaginations, calling each slice-of-time configuration a "pattern." But by stopping the kaleidoscope we have lost the dynamic essence of the dance, for the static "patterns" never in fact existed as discrete entities' (Hayles, 1984: 20)

Alongside this problem of combining scale with flux is the problem of perspective, which turned out to be central to the arguments of *The Cosmic Web*. This 'second group of limitations derives from the lack of an exterior "objective" point from which to observe' (Hayles, 1984: 20). Where the first point is about the problem of the dynamism of the dance, the second is that there is no outside space from which to watch that dance. It is, it was suggested, a question of trying to account for an 'All-of-a-piece dynamic wholeness' (Hayles, 1984: 20).

Hayles continued this exploration of perspective and position by pointing out that:

> 'No matter where we stand we are within the kaleidoscope, turning with it, so that what we see depends on where we stand. To change positions does not solve the problem, because the patterns are constantly changing: what we see when we change positions is not what we would have seen, for in the intervening time the patterns will have changed, and our shift in position will be part of that change' (Hayles, 1984: 20)

Perspective is relative, impacting on the possibilities of description. Hayles sought to bring perspective into the centre of the analysis. Changing position changes perspective, whilst there is also the temporal dimension of change in which that perspective only existed in that moment. The patterns change depending on position and time passing. Here we have the embodied positionality within assemblages that has typified Hayles' (2006; 2012 & 2017) more recent work. In the argument of *The Cosmic Web*, the 'shift from atomistic models to the field concept had the effect of bringing the self-referentiality of language into focus' (Hayles, 1984: 41). There is, it was suggested, 'no way to create a language of observation that will not contain subjective elements' (Hayles, 1984: 40) and it is 'impossible to create such a language'. This goes beyond simple problems of subjectivity, with the interconnection and stickiness of the cosmic web's cultural matrix factored in. There is an inevitability and inescapability to 'self-referentiality'. The result is that the language used 'participates in the interconnection at the same time that it purports to describe it' (Hayles, 1984: 41). There is a relation, immediately, between, Hayles later explained, 'the teller and the tale' and between the 'observer and the observed'. In the metaphor of the cosmic web used by Hayles (1984: 42), this self-referentiality and the relations between observer and observed are crucial to 'the metaphor of the cosmic web' because it is what 'makes the web "sticky"'.

The challenges do not end there of course. Starting to develop the type of embodied knowledge and integrated perspectives that would reemerge in her later works, Hayles argued that the idea that:

> 'limits arise because language is part of the field being described, is at the heart of the revolution implicit in a field concept of reality.The stickiness of this situation, our inability to extricate the object of our description from the description itself, suggests that a more appropriate image for the field concept than the "cosmic dance" is the "cosmic web."' (Hayles, 1984: 21).

What Hayles (1984: 59) showed from the 'various scientific models' was that the 'problem of articulation is intrinsic to this view of reality, whether the language involved is the binary sequence of computer programs, the "wave-packet" equations of quantum mechanics, or one of the syntactically linear natural languages in which scientists attempt to come to grips with the philosophical implications of their models'. The phrase *problematic of articulation* is crucial and captures a core feature of *The Cosmic Web*. Indeed, it is central to its conceptual apparatus. The problem of articulation persists as a concern beyond the book and across Hayles' works, as well as permeating into the fields that that work influenced.

I have mentioned the use of the cosmic web as a metaphor for grasping the field concept. The cosmic web as a metaphor was identified as possessing two key properties: Interconnection and the stickiness of self-referentiality. Hayles (1984: 9) argued that 'perhaps most essential to the field concept is the notion that things are *interconnected*'. As a secondary feature, Hayles (1984: 10) also argued that 'another aspect of the field concept…is the notion of the self-referentiality of language'. Elsewhere in the text this is framed as the 'problem of self-reference' (Hayles, 1984: 36) or stickiness. Hayles explained that we:

> 'may imagine it as a network of strands coextensive with space. Note that the web is not space itself, nor does it "contain" space. Rather it is an artifact, a created object whose artificiality corresponds to the conceptualization of the field models it signifies; what we are concerned with in these models is not reality as such, but conceptualizations that may or may not correspond with whatever we call reality. Imagine further that the web is composed of articulated joints, much as a spider's web is. These joinings will serve as a convenient reminder that the verbal models we shall be examining are also articulated, in the double sense of being utterances and of being composed of discrete units joined together. Once the web is constructed, these joinings may stand for, or gesture toward, a seamless whole.' (Hayles, 1984: 21)

The *web* element of the metaphor denotes both the connections and the stickiness. The notion of *web* foregrounds the 'joints' as well as the linkages. Hayles was interested in the joints and articulations of the web. It was how these joints create a whole, and then how that whole can be understood that was the preoccupation. It is, Hayles concluded later in the text, that 'the task of articulation requires that a vision of a dynamic, mutually interacting field be represented through a medium that is inherently linear, fragmented, and unidirectional' (Hayles, 1984: 59). The problem of articulation is to capture the dynamism of interconnection and stickiness in the linearity of description. This 'tension' of linear description of dynamism and interconnection was a point made most directly through a reading of D H Lawrence (Hayles, 1984: 99). Even if it seems there is a possibility of a 'single, unifying perspective', Hayles points out that the problem

of articulation persists, as ‘we remain within the fragmented consciousness of modern analytical thought’ (Hayles, 1984: 27). This particular point was reiterated within the conclusion that ‘more than any other writer in this study, Pynchon understands what it means to be caught in the cosmic web’ (Hayles, 1984: 27). The cosmic web is something to be caught up within, which impacts upon the possible articulation of its properties.

The problem of articulation of which Hayles spoke translates into various forms when the book moves from general issues to the specific literary texts with which it is concerned. Pirsig for instance, Hayles points out, ‘gives powerful expression to the harmonies that the cosmic web can suggest’ (Hayles, 1984: 83). The problem is that these harmonies exist in tension, or Hayles even goes as far as to use the term paradox. Reflecting on this property of Pirsig’s work, Hayles adds that:

> ‘In devising a rhetorical strategy to cope with the paradoxes that arise when one attempts to speak from within the field, it has raised what is perhaps the most important issue for a literature that attempts to embody this view. That it finally yields to its own consuming desire for order means that, at the end, rational synthesis wins out over the ineffability of the whole.’ (Hayles, 1984: 83)

The key point is that the ineffability, which might be thought of in terms of the problematic of articulation, is maintained but then finally dodged in Pirsig’s conclusion. As Hayles further explains, in ‘allowing the distinction to become blurred between his verbal representation of the field and the field itself, Pirsig in the end draws back from his encounter with the paradox at the heart of the cosmic web.’ (Hayles, 1984: 84). As such, Hayles locates an attempt ‘to try to speak ineffable’ (Hayles, 1984: 84), that ultimately avoids the problem or paradox - thus revealing its presence. This aspect of the problem of articulation can be seen resurfacing in some of Hayles’ (2022: 661) most recent work on AI and the ‘crisis of representation’.

The metaphor of the ‘cosmic web’ also presented Hayles with other descriptive possibilities. For instance, it allowed for a reflection on what might get caught within the cosmic web:

> ‘The prey the cosmic web is designed to entrap is the dynamic, holistic reality implied by the field concept. But the prey always escapes, precisely because the web is articulated; as we shall see, to speak is to create, or presuppose, the separation between subject and object that the reality would deny. What is captured by the cosmic web is thus not the elusive whole, but the observer who would speak that whole. Hence the cosmic web is inherently paradoxical, deriving its deepest meaning from a whole that it can neither contain nor express. Its history can be told as the history of certain paradoxes.’ (Hayles, 1984: 21)

The cosmic web can only be articulated through the single point of time and space of the observer, not as a whole. The observer is captured in the cosmic web. The notion of articulation is crucial in Hayles’ account of how the web forms and takes on its properties of interconnection and stickiness. The cosmic web arrives in these articulations of its own features - which is why it is considered to be self-referential. It is also why the cosmic web derives meaning from its own meaning, which Hayles noted as an acute problem or paradox. Hayles brought forward the problem of wholeness that returned in later analyses of the assemblage (see Hayles, 2017). For these reasons, Hayles (1984: 136) finds that Nabokov’s *Ada* is a ‘tribute to an idea intrinsic to

the field concept, that reality can never be entirely captured in the abstractions of either art or science'. The problem of articulation, this would indicate, cannot be resolved or escaped, it is intrinsic.

The problem in such complex, mobile and vast arrangements is that the whole cannot be fully grasped and so instead the analysis needs to focus upon connections or joints whilst understanding that they are defined by the situation and connections of the unknowable entirety or whole. In this case it is the entirety of the cosmic web, later it would be the relations between instances and whole within a 'cognitive assemblage' (Hayles, 2017). As Hayles (1984: 32) put it in *The Cosmic Web*, the metaphor 'reveals an essential fallacy in the assumption that a whole can always be adequately defined as the sum of its parts'. Here is the combination of self-reference and incompleteness that Hayles developed in *The Cosmic Web* and which also acts as a framing presences for problems that echo in later works, taking in different conceptual forms - including the notion of the 'posthuman' (Hayles, 1999). There is, Hayles (1984: 59) argued, a 'strain of trying to capture that idea of a holistic field in an articulated medium'. It is to this problem of articulation that the literary sources to which Hayles (1984: 59) turned bring their 'own perspective and insights' and offer possibilities for addressing the strain of finding a 'form, and a language, adequate to interpret its human meaning'. The literature, Hayles thought, takes us closer to the problem and provides 'intimations of the complexities symbolized by the cosmic web' (Hayles, 1984: 32).

Conclusion

In an attempt to summarise, Hayles identified two implicit themes: 'one is the extraordinary vision of unity inherent in the field concept of reality; the second is the extreme difficulty of translating this intuitive vision into an articulated model' (Hayles, 1984: 55). Whether or not the arguments and claims about science and literature made in *The Cosmic Web* still hold, or whether they are challenged on the grounds of the ambitious attempt to connect disparate things together, Hayles was establishing conceptual ideas that were to be of importance beyond that one text. The metaphor of the cosmic web brought to the fore interconnection and stickiness along with the problem of their articulation within the context of the webbing of a 'cultural matrix'.

In the 1989 interview mentioned earlier Hayles began to explain a direct connection between *The Cosmic Web* and what was to be the next book, *Chaos Bound* (1990), published the following year:

> 'I see the two studies as very much related. The deeper indications of field concept became apparent in a number of different areas when it was realized that a complete articulation of a formal system was not possible. Had these attempts to articulate completely formal systems succeeded, the result would have been an all-encompassing order. But since they were not possible, the pendulum began to swing the other way, and people became interested in disorder and chaos, in that which escapes resolution and cannot be predicted. It's too early to say where that pendulum swing is going to stop; but the idea that such a swing is happening is central to *Chaos Bound.* The field concept

> had its greatest impact in the first half of the century; in the second half of the century, paradigms of disorder are coming to the fore. *The Cosmic Web* and *Chaos Bound* are complementary in this sense. I like to think that together, each signifies more than it could by itself.' (Hayles in Araas-Vesely, 1989: 7)

After *The Cosmic Web* was published Hayles had become more interested in how the dynamism of the cultural matrix was moving toward disorder. Following their focus on order, Hayles noticed, as explained in the preface to *Chaos Bound*, 'various disciplines became interested in exploring the possibilities of disorder' (Hayles, 1990: xii). It was at that moment that Hayles (1990: xiii) turned to more directly exploring developments in literature and science concerning 'postmodern culture', especially in relation to technologies, along with 'the social landscapes created by the concept of information'. This was why Hayles (1990: xiii) understood *Chaos Bound* as 'both sequel and complement to *The Cosmic Web*' - illustrating how the first book activated certain ideas that would later develop. Though this move toward disorder is also evident in *The Cosmic Web* itself, where Hayles (1984: 99) had already identified ways in which the 'to-and-fro can be destructive as well as synergistic', and how the frictions of the 'to-and-fro' can create 'permanent fragmentation' (Hayles, 1984: 101). This interest in dynamism is suggestive of how lines of thought from the first book were to be picked-up and continued into the later works that have become so influential across embodied studies of technology, posthumanism and into critical data studies. Hayles identified a connection between these two books based around the relations between order and chaos.

Given that it set in motion Katherine Hayles' own work, which in turn has been so influential in shaping interdisciplinary work across fields, *The Cosmic Web* is a foundational text. I have shown here how the concepts of interconnection and stickiness emerge from Hayles' use of the cosmic web metaphor. Yet the influence of this book is in its method as well as its argument. It established Hayles' use of literary texts to explore wider social and cultural forces. It is also an approach that is radically interdisciplinary in its form as well as in its object of study. Notably the metaphor of the cosmic web, which suggests the properties of interconnection and stickiness. These features bring with them, Hayles showed, the problem of articulation. This problem represents an ongoing methodological question that remains with us, and may even have become more profound with the increasing interconnections and stickinessess of contemporary media. What, for instance, are the problems of articulation within the hyper-sticky cultural matrix of algorithmic processing and data analytics? Put bluntly, and without the detailed sophistication with which Hayles posed it, how can we possibly describe such an assembly of bits without cutting them from their interconnections and without missing the experience of the textures and forces they impose?

This article suggests that *The Cosmic Web* has its own web of influence. *The Cosmic Web* is part of the 'cultural matrix' through which critical studies of data, algorithms and AI continue to emerge. It is a book that poses a profound methodological question concerning the problem of articulation. The difficulty of articulating what is happening at the intersections of technology with embodied life, along with the pace and variegation of those intersections, mean that the problem Hayles identified has been amplified. What was the problem of articulation back then, could potentially look now to be *an impossibility of articulation*. Yet Hayles did not suggest that this is a

problem to be resolved, the ambition is to tackle it. By drawing upon literary sources to exemplify the challenges that articulation presents, in *The Cosmic Web* Hayles both set up the problem whilst illustrating one mode of sampling and analysis that can reveal the limits of imagination and creative explication.

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